March 1960

Insulation

Thermoplastic flow of wire film . . . page 19

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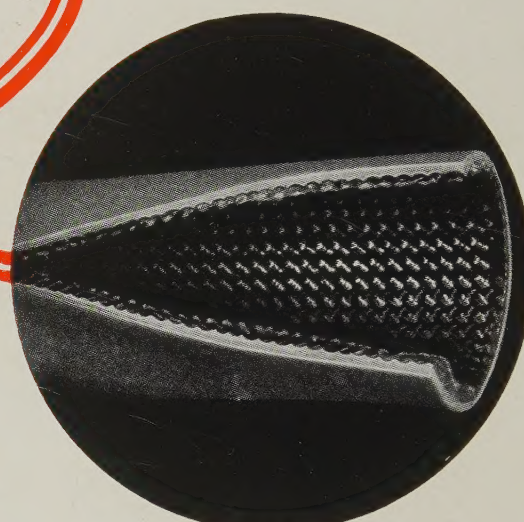
EXTRUSION

makes the difference in

BEN-HAR "1151"

SILICONE RUBBER FIBERGLASS SLEEVING



The super-tough **durasyl** silicone rubber coating of Ben-Har "1151" is so tough and so effectively bonded to the supporting braid that breakdowns caused by pushback, abrasion or rough handling are eliminated. Applied by a new extrusion process, **durasyl** is so flexible that expansion up to a 400% increase of a.w.g. size is possible, minimizing tolerance problems.

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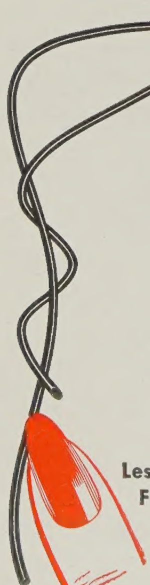

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300 BARCLAY STREET **CONSHOHOCKEN 6, PA**
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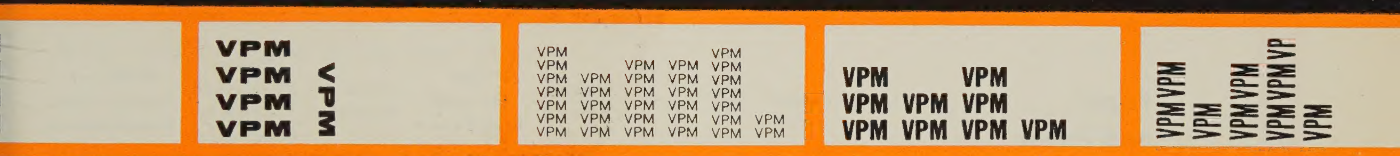
Print Ins. 2 on Reader Service

DIELECTRIC STRENGTH STOCKED IN ALL SIZES AND TYPES



ielectric strength may be just one of many properties which concern you when you purchase an insu-ating material. The important thing to remember is that you are buying more than just a material—ou're buying properties that meet your needs.

rehler has huge warehouse stocks of nearly every conceivable type of insulation. These materials are tocked on the basis of how they will fit your requirements. This means that Prehler is stocking the mount and type of insulation properties you require. You're sure to find the dielectric strength, mechan-cal characteristics, and resistance to heat, chemicals, moisture, and other conditions you require at rehler. Learn about Prehler's complete, conveniently located stocks by calling your nearest office, now.

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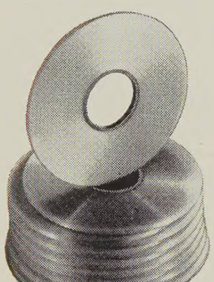
Everything in Precision-Slit Electrical Insulation

Inmanco®

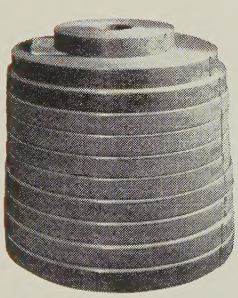
Thin Film and Film Combinations



MATERIALS	Mylar†	Cellulose Acetate	Teflon†	Polyethylene	Mylar-Dacron† Matte Combinations
NOMINAL THICKNESSES	.00025″ through .010″	.00088″ through .010″	.002″ through .015″	.0015″ through .010″	.008″ .009″ .011″
AVAILABLE WIDTHS	⅛″ and up	¼″ and up	¼″ and up	¼″ and up	⅛″ and up
NORMAL TOLERANCES IN WIDTH	±.010″				
STANDARD O.D. COILS ½″ AND WIDER ON 3″ I.D. CORES	Maximum 9½″				
STANDARD O.D. COILS UNDER ½″ WIDE ON 3″ I.D. CORES	4″ to 6″				

† DuPont Trademark.

Paper and Paper Combinations



MATERIALS	All-Rag Papers	Tan Electrical Kraft Papers	Fibre or Fishpaper	Paper-Varnished Cambric Combination	Mylar† or Acetate-Paper Combinations
NOMINAL THICKNESSES	.005″ .007″ .010″ .015″ .020″ .025″	.005″ .007″ .010″ .015″ .020″	.004″ to .031″	.010″ through .028″	.006″ through .021″
AVAILABLE WIDTHS	3/16″ and up	3/16″ and up	1/16″ and up	3/16″ and up	3/16″ and up
NORMAL TOLERANCES IN WIDTH	Coil widths under 1″, ± 2%; Coil widths 1″ and over, ± 1/32″ or 1%, whichever is greater				
STANDARD DIA. COILS ANY STANDARD CORE SIZE	Approximately 15″ O.D.				

† DuPont Trademark.

Materials and sizes listed above represent the most widely used forms of slit electrical insulation. However, the scope of INMANCO's facilities offers many other variations, such as special put-ups, materials, and windings. INMANCO slit coils are made from nationally recognized products or from material which you supply. This, together with a specialist's "know-how," assures you of uniform, hard coils with smooth edges and precision tolerances.

Big orders, small ones, special tolerances, unusual slitting jobs—INMANCO engineers and facilities can give you exactly what the job requires.

WRITE FOR BULLETIN 33

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Print Ins. 3 on Reader Service Card

Insulation

For the Electrical and Electronic Industries

Lake Publishing Corporation, 311 East Park Ave., Libertyville, Illinois, March 1960

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From the Editor

Opinions and Rambling Thoughts

Now Is the Time to Volunteer!

Work is well underway on the 3rd Annual National Conference on the Application of Electrical Insulation to be held at the Conrad Hilton Hotel in Chicago the week of December 5th. Plans for making the conference bigger and better than last year are in the works—and now the time is fast approaching when willing volunteer workers are needed to carry out these plans. Volunteers are needed in two areas—committee work and technical programming.

Thomas F. Hart, Silicones Div., Union Carbide Corp., New York City, is general chairman of the program committee. He is being assisted by J. S. Hurley, Silicones Dept., General Electric Co., Waterbury, N. Y., and R. W. Jorgenson, The Richardson Co., Melrose Park, Ill. It is planned that the technical program will be end-use centered with sessions covering electronic components and equipment, rotating machinery, and distribution and control apparatus. Suggestions are desired from everyone interested in the insulation field, both as to topics for papers to be presented and qualified authors. If you take just a few moments now to make suggestions, there is a much better possibility that the subjects being presented at the 1960 conference will be of extreme interest to you. It also follows that as the number of suggestions and offers to present papers increase, there will be a corresponding opportunity to develop a program of the highest possible calibre and importance. The best chance for making the technical program one that will help you in your work is to make your views known and to offer your assistance now to one of the program workers.

Volunteers for all types of committee work are needed both in Chicago and throughout the country. So that you can offer your services to the persons concerned in the types of work you prefer, there follows a listing of some of the conference officials: William Hoffer, general conference chairman, Johns-Manville Corp., New York City; Roger White, vice chairman of technical arrangements, The Glastic Corp., Cleveland; Michael Nakonechny, vice chairman of commercial arrangements, Dow Corning Corp., New York City; A. S. Gray, chairman, local arrangements committee, Insulation Manufacturers Corp., Chicago.

Also, general program chairman, Thomas F. Hart, Union Carbide Corp., Silicones Div., New York City; E. J. Phelan, chairman, marketers' meeting, Prehler Electrical Insulation Co., Chicago; Geoffrey Brown, promotion and publicity chairman, Silicones Div., Union Carbide Corp., New York City, with the assistance of Robert Bloor, Dow Corning Corp., Midland, Mich., and Frank C. Osterland, Allis-Chalmers Mfg. Co., Motor and Generator Dept., Milwaukee, Wis.; Walter Hugger, chairman, special arrangements committee, Electro-Technical Products Div., Sun Chemical Corp., Nutley, N. J.; and Charles O. Newlin, treasurer, Continental Illinois National Bank & Trust Co. of Chicago.

Something New Has Been Added

You will notice that *Insulation's* Reader Service cards are now attached to the back cover. You can fold them out and mark down reader service numbers as you read the magazine. They are easy to find and help eliminate page turning. Fill them out, tear off, and mail postage-free.

The Cover

The cover this month is artist Randall R. Roth's concept of the article in this issue titled "The Measurement of Thermoplastic Flow of Film Coated Magnet Wires" by M. V. Thierry, development chemist with the Magnet Wire Div. of Essex Wire Corp. in Fort Wayne. The article explains a new thermoplastic flow test method which will be of interest to every producer and user of magnet wire—which means just about every reader which is why it was featured on the cover. Be sure to read it.

Other Features

As usual there are many other features that you will find helpful in this issue of Insulation. For those of you who were not able to attend the recent meetings of the Society of Plastics Engineers and the American Association of Electrical Engineers, the editors have prepared reports on some of the important insulation papers which were presented at these meetings. The SPE report covers epoxy resins, alkyd molding compounds, low loss casting resins, and polyvinyl chloride resins. Subjects of some of the papers at the AIEE meeting reported on in this issue include: motor insulation systems, inorganic insulation, thermal life test data, radiation effects, breakdown of liquid dielectrics, varnished cloth, magnet wire, and high temperature transformers.

Dr. V. J. Linnenbom's excellent series of articles, "The Effects of Radiation on Materials," is concluded in this issue with a discussion of the effects of radiation on insulating materials. Also in this issue, author H. K. Graves, discusses the coefficient of thermal conductivity test.

Naturally, there are many more editorial articles and features in this issue which will assist you in your work . . . and additional excellent articles are lined up for the future.

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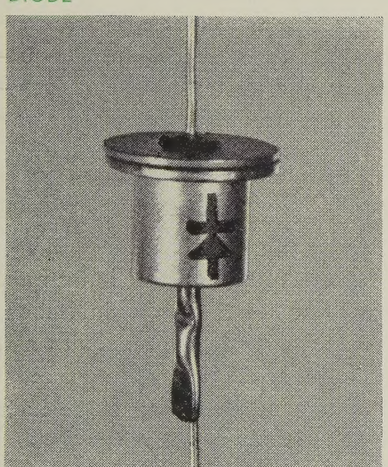

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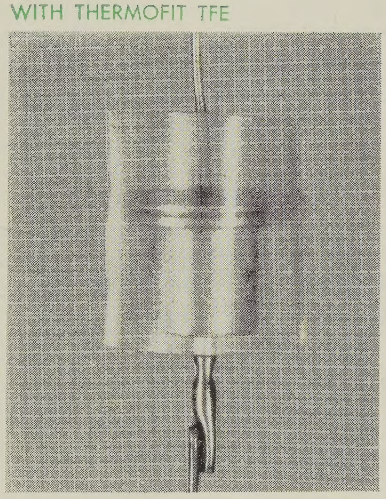

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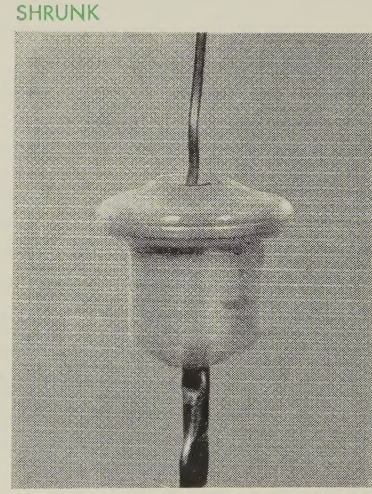


News and Views

Alcoa Buys Rea

Aluminum Co. of America, in a move designed to speed up the use of aluminum in the magnet wire field, has purchased Rea Magnet Wire Co. Inc. in exchange for common stock. Rea, which has made a name for itself in the manufacture of smaller sizes of copper magnet wire, was founded in 1933 and employs about 770 people at plants in Fort Wayne and Lafayette, Ind. Alcoa plans no changes in policies, personnel, or operation of Rea. Rea will be operated as a subsidiary of Alcoa.

Commercial Production of New Plastics

Mobay Chemical Co., Pittsburgh, has announced that commercial quantities of "Merlon," Mobay's polycarbonate resin, will be available this spring from production facilities which are nearly complete at the new Martinsville, W.Va. plant. The new thermoplastic material is expected to be used in a number of electrical and electronic components. Electrical and mechanical properties of the molded plastic reportedly remain stable between —40°F and a heat distortion point of 280 to 290°F. It is self-extinguishing. Some of the experimental applications for which the material has been evaluated include insulators and insulating board and mountings; cable wrapping; capacitors; distributor caps; meter bases; telephone sets; computer components; wiring connectors; coil forms; and motor slot liners.

DuPont's facilities for commercial production of "Teflon" 100 FEP-fluorocarbon resin are now in operation. Price of the new resin is $11.60 a pound in truck-load quantities which compares to the previous pilot plant price of $19 a pound. The resin is expected to be used widely for electrical insulation purposes. DuPont's Film Dept. is marketing films made from "Teflon" 100 with coils, capacitors, and printed wiring being viewed as promising uses for the film.

Price Reductions

Price reductions on flexible "Teflon" tubing for insulating leads and wires reportedly have been made by Pennsylvania Fluorocarbon Co. Inc., Philadelphia. The reductions cover both the standard and thin wall thicknesses. Early last month, Dow Corning Corp., Midland, Mich., announced that prices of all its "Silastic" LS (fluorosilicone rubber) stocks would be lowered approximately 25% bringing the price down to less than 50% of the original $30 a pound price. Allied Chemical's National Aniline Div., New York, has cut the price of Succinic Anhydride 23 cents per pound bringing the price down to 51 cents per pound in truck-load quantities and 52 cents per pound in less than truck-load amounts. National Aniline hopes that the price reduction will stimulate applications for the compound in polyester resins, polyester-based flexible polyurethane foams, and as an intermediate for plasticizers and alkyd resins.

Commercial Chemical Products By Nuclear Reactor Treatment

According to Hercules Powder Co., radically new chemical processes may be used to produce commercial chemical products by treatment of basic organic raw materials in a nuclear reactor. Hercules scientists reportedly have developed a design concept for a new type of nuclear reactor on which practical development of the new processes may be based. Preliminary cost estimates suggest that this could be the first peacetime application of atomic energy capable of competing with standard chemical manufacturing techniques.

FMC Enters Epoxy Resin Field

Food Machinery and Chemical Corp., New York, has entered the epoxy field with the introduction of a new series of epoxy resins which reportedly are very different from conventional epoxies in molecular structure. Known as the "Oxiron" series, the resins are claimed to provide processing advantages as well as improved end properties including high temperature stability, electrical properties, and strength.

Plastics Growth

According to the Society of the Plastics Industry, plastics production increased 25% last year to 5.6-billion lbs. having a value of about $3-billion compared with a value of $2½-billion in 1958. The 25% growth exceeds the original expectation of only 10%. Although the industry has indicated that it plans to expand 25% in 1960, SPI estimates that production will be up only 15% because of available facilities. Specific percentage increase gains for 1959 over 1958 are estimated as follows: Cellulosics 12%, phenolics 20%, polyesters 28%, polyethylene 38%, polystyrene 18%, urea and melamine 15%, vinyls 26%.

At the 15th Annual Conference of the Reinforced Plastics Division of the SPI, Donald G. Patterson, vice president plastics, Reichhold Chemicals Inc., predicted that the plastics industry would achieve sales of 6-billion pounds in 1960 and would reach 10-billion pounds in 1965. At the reinforced plastics meeting A. W. Levenhagen, chairman of the division, reported that sales of reinforced plastics rose 42.5% in 1959 compared to 1958 and were kept from going higher only by the shortage of fibrous glass. Estimates for 1960 range from 10 to 20 percent over the 264-million lbs. sold in 1959.

In Hot, Humid Climates, Polyester Varnishes Help Prolong Equipment Life.

An interview with J. W. McHugh, Vice President
Schenectady Varnish Company, Inc., Schenectady, N. Y.

Polyester insulating varnishes are noted for their superior heat life compared to other organic varnishes. The following discussion describes another outstanding characteristic — moisture resistance — and its significance to the electrical engineer.

). In addition to their heat resistance, what other advantages do olyester varnishes offer electrical quipment manufacturers?

A. Speaking only about ISONEL® polyester varnishes made by ur company, they have exceptional ond strength, excellent penetration nd dip tank stability, and complete ompatibility with most magnet ires. They are adaptable to automatic dipping equipment and high elocity ovens in fast cycles and have xceptional moisture resistance. They ome close to being the long-sought universal" varnishes.

). Moisture resistance is a characteristic which has received a ood deal of attention recently. What vidence is available on the moisture esistance of polyester varnishes?

A. The exceptional moisture resistance of these varnishes was rst noted in our laboratory, then onfirmed in a government laboratory when they were tested against e MIL-V-1137A specification. Results showed:

1. Wet dielectric as high as 3030 vpm (compared to 1000 vpm or less for many widely used phenolic varnishes.)
2. Insulation resistance after 240 hours in water as high as 1.2 x 10^6 megohms.
3. The 100-hour salt water test was passed with plenty to spare.

In addition, independent laboratories have confirmed their superiority to most general-purpose, oil-modified phenolic varnishes now in use. Field experience has verified these results.

Q. Several tests in the MIL-V-1137A specification are water immersion tests. How do these varnishes stand up under high humidity conditions?

A. Very well. For example, one manufacturer of small transformers for military receivers used in the tropics cited extreme moisture resistance as one of his prime requisites. Exhaustive tests involving several hundred transformers and a number of insulating varnishes were conducted. The test units were all vacuum impregnated, cured for 2 hours at 325 F, then placed in a 96% R.H. atmosphere at 100 F. Their insulation resistance was measured daily for 7 days. At the end of the test, the units impregnated with ISONEL 31 Varnish averaged 1000 megohms compared to only 10 megohms or less for most of the other varnishes. Production units, therefore, were made with ISONEL varnish.

Q. What results have been obtained in actual field experience?

A. Some units have been exposed long enough now to answer this question. For example, one manufacturer producing motors for use in Gulf Coast oil refineries (subject to high humidity, chemically corrosive atmosphere) found these failed 6 weeks to 2 months after going into service. An ISONEL 31 Varnish/ISONEL Enameled Wire* system was recommended. Motors so treated have now been running over 6 months — all through the hot, humid summer months — and are still going strong.

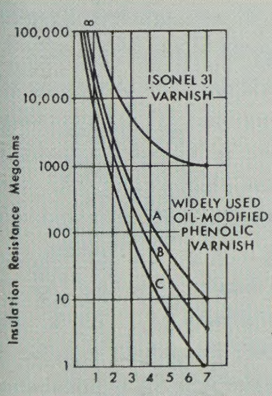
Q. Is this an isolated incident?

A. No. When the electrical system of the Panama Canal was converted from 25 to 60-cycle operation, a well-known manufacturer contracted to supply some 1100 motors, ranging from fractionals up to 700 hp. These not only had to operate at overloads when necessary, but must start up readily after standing idle for long periods under extreme humidity. Again, after extensive humidity chamber tests at 100% R.H. and 60 C, ISONEL impregnated stators showed the highest resistance to ground of any tested. An ISONEL varnish/polyester enameled wire system was used. To date (over 2 years later) no failures have occurred.

Q. What is the significance of this to electrical engineers?

A. Although field experience is still limited, it does seem apparent that engineers can use polyester varnishes to advantage over a much broader range of applications than any other organic varnishes. The steady increase in demand for polyesters also indicates their utility.

* Consult your wire supplier for data on ISONEL enameled wire.



Insulation Resistance of ISONEL 31 High-Bonding Varnish vs. Phenolic Varnishes After 7 Days At 96% R.H. and 100 F.

Inquiries should be directed to: Section E-02

In Canada: Schenectady Varnish Canada, Ltd.
309 Comstock Road
Scarborough, Toronto, Ont.

In Mexico: Schenectady Varnish de Mexico, S.A.
M. Antonio Casa No. 28 1er
Mexico 4, D.F.

In France: Schenectady de France
11, Avenue Kleber
Paris 16e

SCHENECTADY VARNISH COMPANY, INC.
SCHENECTADY 1, N. Y.
Insulating Varnishes and Wire Enamels for the Electrical Industry

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Gold Used on Printed Circuits in Aircraft

Printed electrical circuits and contacts made from copper for use in aircraft and missiles are coated with gold by Chance Vought Aircraft to extend the storage life and improve solderability by increasing resistance to oxidation and tarnish. The .000002-inch thick coating is said to be lightweight, economical, and continuous.

Gold also has many other uses in aero-space vehicles because of its high heat reflectivity, relatively high melting point, low spectral emissivity, and excellent corrosion resistance. For instance, the inner skin of the "Scout" research rocket has more than 100 square feet of gold plating to protect scientific instruments from the extreme heat caused by atmospheric friction. This plating is .00001-inch thick and costs only 60 cents a square foot to apply. Gold coatings can also be used to prevent structural heating of planes, lessening the danger of infrared detection. A sizeable reduction in costly structural weight may also be realized by gold coating in the engine area.

Minor Changes in ASESA Qualification

A change in the procedure for handling minor design-and-construction changes in products which are currently qualified by the Armed Services Electro-Standards Agency allows the manufacturer to determine the extent of testing required. (A minor design-and-construction change is defined as one which will not significantly affect the performance of the product.)

No authorization for testing or witnessing signature of a government representative is necessary. However, the signature of a responsible company official verifying the test data is required.

Further details relating to test equipment, filing of reports, etc., under the new procedure may be obtained from the ASESA Qualifications Div., Fort Monmouth, N. J.


225%
AVERAGE
ABOVE
SPEC
600%
AVERAGE
ABOVE
SPEC
TEST VOLTAGE
AWG SIZES

Low-cost insulation problems? Look into these CDF Dilecto® laminates

Fabricated by CDF. Near the presses that produced the Dilecto laminates, these paper-base parts were machined to close tolerances by CDF specialists . . . quickly, accurately, economically for the purchasers. This is a random selection from the five grades described in the table below.

For everyday mechanical-electrical parts that receive tough punishment and must have excellent physical and dielectric properties at low cost, the CDF phenolic paper-base line is outstanding.

Economy. CDF paper-base grades machine readily into intricate parts. Some are flame-retardant. Others are especially adaptable for punching. All are economical for the value delivered.

Fabrication Facilities. CDF has excellent and extensive plastics-fabrication facilities for turning out finished Dilecto parts to your specifications—better and more economically than you can do it yourself. Save the time and trouble of intricate fabrication by using CDF's specialized facilities.

See Sweet's, Electronics Buyers' Guide, and the other directories for the phone number of the CDF sales engineer nearest you. Or send us your print or problem direct, and we'll return a recommendation of the right Dilecto grade for your need.

CDF makes Di-Clad® printed-circuit laminates, Diamond® Vulcanized Fibre, CDF products of Teflon†, flexible insulating tapes, Dilecto® laminated plastics, Celoron® molded products, Micabond® mica products, Spiral Tubing, Vulcoid®.

†Du Pont trademark for its TFE-fluorocarbon resin

CONTINENTAL-DIAMOND FIBRE

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In Canada: Continental-Diamond Fibre of Canada Ltd., 46 Hollinger Road, Toronto 16, Ont.

Typical Property Values—Dilecto Paper-Base Laminates in Sheet Form

	X-13 (NEMA X)	XP-13 (NEMA P)	XX-13 (NEMA XX)	XX-13 FR (Fire-retardant) (NEMA XX)	XXXP-28 (NEMA XXXP)
ROCKWELL HARDNESS (M SCALE)	100	95	110	108	90
TENSILE STRENGTH lw (1000 psi.)	20	12	16	17	12
FLEXURAL STRENGTH lw (1000 psi.)	27	16	17	20	18
COMPRESSIVE STRENGTH (1000 psi.)	40	25	35	41	22
WATER ABSORPTION (% in 24 hrs.) 1/16″ thickness	3.5	3.0	1.4	1.2	0.6
MAXIMUM CONTINUOUS OPERATING TEMPERATURE (°C.)	120	120	120	120	120
DIELECTRIC STRENGTH perp. to lam. (VPM)	800	800	650	700	800
DIELECTRIC STRENGTH parallel to lam. (Kv.)	50	50	60	70	75
DISSIPATION FACTOR at 1 mc, Cond. A	0.042	0.038	0.034	0.038	0.027
DIELECTRIC CONSTANT at 1 mc, Cond. A	5.5	4.6	4.7	4.8	3.6
ARC-RESISTANCE (seconds)	8	4	4	10	10
INSULATION RESISTANCE (megohms) ASTM D-257, Fig. 3	100	100	1,000	1,000	600,000
AIEE insulation class	A	A	A	A	A

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The Effects of Radiation on Materials

Part 3—Radiation Damage Mechanisms: Insulating Materials

By V. J. Linnenbom, Head, Radiation Effects Branch, Radiation Div., U. S. Naval Research Laboratory, Washington, D.C.

The ability of any material to conduct electricity depends on two things: (a) the number of carriers which are available to carry the current, and (b) the mobility of these carriers when an external electric field is applied. An insulator, therefore, is a material in which at least one of these prerequisites for conduction is not met. Basically, there are two kinds of carriers, free electrons and charged ions (i.e., atoms which have lost electrons*). An organic insulator, such as a plastic, fails to conduct current simply because the number of carriers available is too small; ions as such do not exist in these compounds, and the valence electrons which are shared between the atoms are held so strongly by the exchange forces of the covalent bonds that they cannot be considered as free to act as carriers. Glass, on the other hand, is an example of an insulating material in which carriers, although present, possess a very limited mobility under ordinary conditions. At elevated temperatures, however, these carriers (which are positively charged sodium ions) show an increased mobility, and glass exhibits an increasing conductivity as the temperature rises.

Any process which changes either the number or the mobility of the carriers in a material will therefore affect the electrical conductivity of that material. The positive effect of temperature on the mobility of the carriers in glass has already been mentioned. In metals, on the other hand, the electron mobility is found to decrease as the temperature rises. This is responsible for the well-known fact that the resistivity of most metals increases with temperature. In either case, the number of carriers remains essentially unaltered; it is the change in carrier mobility which affects the conductivity.

In semiconductors, not only the mobility but also the number of carriers are affected by temperature. Often only a moderate increase in temperature is sufficient to increase the number of carriers by exciting electrons across the comparatively narrow forbidden band into the conduction band. In this process, thermal energy is utilized to do the work involved in raising electrons from a bound state (where they cannot act as carriers) to a free state. Insulators have a much wider forbidden band, and much larger energies are required to move electrons into the conduction band. If thermal energy is utilized to do this work, the required temperature increases are so great that for many insulators with only limited stability towards heat (e.g., organics), the material either melts or is destroyed before appreciable conduction sets in.

Absorption of energy from radiation can also affect the number and mobility of carriers. In metals, the number of free electrons is already so large that the additional carriers produced by radiation have a negligible effect on conductivity. In insulators, however, the number of free electrons ordinarily present is quite small, so that the radiation-induced change in conductivity can be relatively large. The magnitude of this particular effect, and whether it is temporary or permanent in nature, depends to a large extent on the structure and composition of the material. Thus, when free electrons are formed in an insulator during irradiation, they will move under the influence of an applied electric field and thereby form a current. However, since electron traps exist in any insulating material (e.g., in the form of lattice imperfections), the conductivity at any given instant will be directly proportional to the rate at which the free electrons are being formed, and inversely proportional to the rate at which these free electrons are being trapped. That is, if the electrons are trapped almost as fast as they are produced, the number of free electrons at any given instant will remain small, and the resistivity will remain high. Obviously, it is only while the electrons remain free to move that they can carry current. The width of the forbidden gap, the number of traps, and the trapping time are all structure-sensitive and will differ from one material to another. In the same radiation field, different materials will therefore show different induced conductivities.

On the basis of this picture, it is clear that at first the conductivity induced during irradiation should be proportional to the radiation intensity, i.e., the dose rate, since this determines the rate of production of free electrons. Experimentally, it is found that the induced conductivity in-

**Analogous to electron conduction is a process called positive hole conduction. When an electron is excited into the conduction band of an insulator or a semiconductor, it leaves behind an electron vacancy, which can be thought of as a positively charged hole. The hole is free to accept an electron from a neighboring atom; this process creates a new hole in the adjacent position at the same time that the first hole disappears. Drifting of the positive hole is thus pictured as taking place by a series of replacements, and for this reason is usually slower than the movement of free electrons. In a similar manner, migration of lattice vacancies created by atom displacement is said to occur.*

creases to a constant value very soon after the start of the irradiation, this value being dependent mainly on the dose rate. However, as the irradiation is continued, permanent damage effects due to total accumulated dose begin to assume some significance; the induced conductivity begins to change again rather slowly, and its value now becomes a function of both dose rate and total dose. For a given material, therefore, the induced conductivity during irradiation will at first be determined mainly by the dose rate, but with prolonged irradiation times, may become dependent on total dose as well.

Whether the induced conductivity persists for any time after the irradiation has ceased depends on the rate at which the electrons are released from the traps during the post-irradiation period. This annealing rate will be proportional to the rate at which thermal energy is made available (i.e., the post-irradiation ambient temperature), and inversely proportional to the energies required for removal (i.e., the "depth" of the traps). High post-irradiation temperatures, or very shallow traps, result in disappearance of most of the induced conductivity within a very short time after the irradiation has ceased. Low temperatures and deep traps, which result in a very gradual release of electrons with time, lead to a persistence of much of the induced conductivity for periods up to several days or more after removal from the radiation field. The change in induced conductivity following irradiation is usually exponential in nature; at first there is a very rapid drop, but then the decrease becomes slower and slower until finally there remains a very small induced conductivity which may persist for months.

This simple picture of the mechanism of radiation-induced conductivity in insulators must be used with caution, especially with the organic type insulators, where the band theory of the solid state may not be strictly applicable. Complicating effects such as acccumulation of space charge tend to obscure the picture. Post-irradiation annealing often does not depend upon temperature in the manner expected. Ionic conductivity is not accounted for in the above explanation. Permanent radiation damage is another complicating factor. And often conflicting reports in the literature make it difficult to arrive at a consistent theory by the inductive method used in scientific investigation. To cite an extreme example, the induced conductivity in polystyrene during irradiation has been reported in one case to have increased by a factor of 10^8, but in another investigation under similar conditions, the reported increase was only 10^3. Notwithstanding these shortcomings, it is felt that the above theory provides what is essentially the basic explanation of temporary radiation-induced conductivity.

Permanent changes resulting from radiation have been mentioned. With the organic insulators, the permanent radiation damage is usually more of a problem than transient effects. It has already been pointed out that the ionization and excitation processes in such materials lead to the breaking of chemical bonds, followed by a complex series of irreversible chemical reactions which permanently change the nature of the material. Since the number of bonds broken is determined by the amount of energy imparted to the material, it follows that the extent of the permanent damage depends mainly on the total radiation dose, rather than the dose rate. This is in contrast to the conductivity induced during irradiation, which in general depends on the dose rate. It cannot be emphasized too strongly that given a sufficiently high dose all organic insulators deteriorate, and are thus not suitable for extended use in a high radiation field.

Polytetrafluoroethylene ("Teflon") insulation, for example, will become brittle, discolored, and eventually crack and disintegrate. Gas evolution in solid organics such as polymethylmethacrylate ("Lucite") causes expansion and foaming. Varnish and resin coatings become sticky. Rubber becomes very brittle and susceptible to cracking. Fabric coating may fall apart. A halogenated compound such as polyvinyl chloride will release hydrochloric acid vapor which is exceedingly corrosive and will cause damage to nearby components. Gas evolution in fluids such as transformer oils can generate undesirable high pressures in the containment vessel. Eventually, such reactions as these completely destroy the value of these organic materials as insulators.

From the standpoint of prolonged use in a strong radiation field, where large doses are accumulated, these chemical and physical changes which lead to permanent damage are what generally determine the failure of organic type insulators, rather than any marked change in electrical properties. For short term use, however, where total dose remains small, induced conductivity during irradiation, and thus the dose rate, becomes important. In either case, it should be apparent from what has been said previously about temperature effects that other environmental factors besides radiation cannot be ignored. In addition to temperature, humidity and the presence or absence of atmospheric gases such as oxygen must be simultaneously considered along with the radiation. For example, ozone is formed from oxygen in strong radiation fields, and this particular compound has been found to accelerate the radiation-induced deterioration of many organic materials.

From a design standpoint, the importance of testing not only the performance of the insulating material itself in the radiation field, but also the component of which the insulator is a part, cannot be overemphasized. For example, if a polyethylene coated wire is under consideration, measurements on the coated wire itself should be carried out in the presence of the radiation, rather than measurements on the electrical properties of polyethylene alone. This is because under irradiation the insulation takes on some of the characteristics of a semiconductor, and the contact between the conducting wire and the semiconductor produces certain effects which would be missed if the insulation alone were tested, such as rectification and other aspects of nonohmic behavior. Or, if a capacitor containing a certain dielectric as insulator is planned to be used, the

capacitor as a unit should be tested, rather than the dielectric material above.

Another aspect of such testing is the importance of the surrounding atmosphere. In any actual electrical set-up, air always acts as an external insulator and dielectric. In many cases, the gas which surrounds the components is one of the most sensitive parts of the entire circuit. The effects of ionization and increased conductivity in the surrounding atmosphere must therefore be considered. A radiation-induced conductivity has sometimes been erroneously reported for certain materials when the measured effect was actually due to ionized air surrounding the material under test.

This distinction between testing components and testing materials applies also to the concept of post-irradiation testing vs. testing during irradiation. The former type of testing measures only residual effects which persist after the material, or the component, is removed from the radiation environment. While it is important to measure these post-irradiation effects, the two types of measurements are not equivalent, and conclusions about behavior during irradiation which are based on post-irradiation tests must certainly be tentative and used with a great deal of caution.

Inorganic insulating materials (glass, quartz, aluminum oxide, magnesium oxide, mica, etc.) suffer far less permanent damage than the organics. Atomic displacements, rather than the ionization and excitation processes which lead to the irreversible chemical changes described above for organics, are responsible for practically all the permanent damage to inorganics. In a few cases, where elements having a high probability for thermal neutron capture are present (e.g., boron), transmutation processes may result in the production of foreign atoms in the crystal lattice. These effects show up as structural changes, such as density variations and volume expansion. This is usually the cause of failure after prolonged irradiation, since this type of dimensional change can lead to cracking and breaking off of these brittle materials. In most cases this physical failure occurs before any significant permanent change in electrical and insulating properties has taken place.

Temporary induced conductivity during irradiation is produced in the inorganic insulators, just as in the organics. The same mechanism—excitation of electrons into the conduction band—is considered to be responsible. In general, the induced conductivity in the inorganics is greater than that found in the organic materials, since the mobility of the current carriers is usually higher in the inorganic insulators. However, from a relative standpoint, the resistivity of the inorganic materials, particularly the ceramic oxides, still remains sufficiently high so that the disadvantage of induced conductivity during irradiation is far outweighed by their resistance to permanent damage.

In general, with the inorganic insulators, gamma radiation will produce only a temporary induced conductivity which in most cases should not materially affect the performance of these materials as insulators. Neutrons, because of the permanent effects produced, are far more damaging. Temperature effects on the inorganic oxides are much less serious than with the organics. Not only will the ceramics withstand exceedingly high temperatures during irradiation without harm, but it may actually turn out that the annealing effects of the high temperatures may be beneficial insofar as the removal of radiation-induced structural defects are concerned.

Thus far, the discussion has centered about radiation-induced conductivity, which is largely a transient phenomenon, and on those permanent changes in the physical and chemical properties of materials which impair their usefulness as insulators. These are probably the most important effects which radiation produces on insulating materials. Changes in other electrical properties, however, also occur. For example, the over-all dielectric loss observed in a material includes other factors besides the direct ohmic loss due to induced conductivity. If the external field is an alternating one, then the electrostatic stresses in the material will be periodically reversed, due to dipole re-orientation,* and there will be an additional dielectric loss. The result is that an insulator at one voltage and frequency may be satisfactory in a given radiation field, but may perform poorly at different frequencies. The dielectric constant of a material is related to the degree of polarization of the atoms and molecules of which it is composed. Any mechanism, such as cross-linking or degradation in irradiated plastics, which tends to interfere with the freedom with which these polar groups can orient themselves in an external field, will affect the magnitude of the dielectric constant. A complete testing program on the effects of radiation on dielectrics would therefore include measurements not only on the radiation-induced conductivity, but also on changes in dielectric constant, breakdown voltage, corona effects, and over-all loss factor. However, it must be emphasized that in many cases physical or chemical deterioration of a material may set in before the changes in electrical properties become significant.

Whether or not a material will give satisfactory service in a given radiation field depends of course on the particular application. For extended, long-term use, it is necessary to arrive at some estimate as to the probable lifetime of the material in the particular radiation field involved, that is, the time it takes for the material to accumulate the dose beyond which it is no longer useful. The purpose of a testing program is the determination of this dose. Once this dose has been determined, it is then possible to make a reasonably reliable estimate as to the lifetime in any radiation field. On this basis of useful lifetime in a radiation field, one may list several typical insulating materials in the order of decreasing radiation stability: ceramics, mica, glass, polystyrene, "Mylar," polyethylene, "Lucite," silicone rubber, nylon, and "Teflon."

If the material is being considered only for short-term use, where total dose does not accumulate to any significant extent, then temporary phe-

nomena such as induced conductivity during irradiation will largely determine the usefulness of a material in the radiation field. In this case, dose rate, rather than absorbed dose, becomes the significant variable which affects the performance. On this basis, it is somewhat more difficult to compare materials with respect to radiation stability, since the available data in most cases were not obtained at comparable dose rates. Published data on the resistivity changes of ceramic insulators during irradiation are scarce; most measurements have involved only a comparison of pre- and post-irradiation tests. In general, if the temperature is not too high and extended usage is not contemplated, the plastic insulators, having higher resistivities over-all than the ceramics, would be preferable. Considering only the plastics, on the basis of equilibrium values of resistivity reached during irradiation, it is found that "Mylar," polystyrene, and "Kel-F" head the list (there is considerable disagreement in the literature as to the relative positions of polystyrene, "Kel-F," and "Teflon"), followed by "Lucite," Teflon, and polyethylene. It is interesting to note that on the basis of total lifetime, polyethylene is one of the better plastics, whereas on the basis of induced conductivity during irradiation, it seems to be one of the poorer.

Suppose that a company wishes to bid on a job of supplying equipment for use in a radiation field. This equipment may contain one or more insulated components ranging from the simple, such as insulated thermocouple leads, to the complex, such as pumps used to transport the heat transfer fluid from the core of a reactor through the heat exchangers and back to the core. In this latter case, the insulating material must withstand not only a high flux of radiation but also a high ambient temperature. Usually, the specifications upon which the bid must be based will require (among other things) that the equipment withstand a given radiation field for a given time of operation. Now from purely electrical considerations the engineer who is responsible for making out the bids will probably already have in mind a suitable insulating material. He must now decide whether this material will stand up under the prescribed operating conditions, taking into account not only the radiation but the environment as a whole, including temperature, humidity, moisture, vibration, etc.

His first step should be a survey of existing radiation effects data on insulating materials. If, on the basis of this survey, he decides that the insulating material he had in mind will most likely be unsuitable for prolonged use in the given radiation field, several alternatives suggest themselves. First of all, substitute materials should be considered; in particular, in high radiation fields the use of ceramic insulators becomes almost mandatory. Because radiation damage to ceramics usually leads to fracture and cracking, it may be necessary to provide some sort of mechanical support. Use of a powder enclosed in metal tubing, rather than a fused ceramic, may be the answer. If flexibility is necessary, or if electrical considerations dictate the use of organics, a judicious choice of materials based on known radiation effects data plus local shielding to reduce the radiation intensity may solve the problem. For example, boron-containing plastics surrounding the insulating material may be used for neutron shielding; the hydrogenous plastic serves to slow down the fast neutrons, and the boron serves to absorb the neutrons after they have become thermalized. When shielded by such material, the insulator is subjected to a greatly reduced neutron flux. If this is not feasible, it may be necessary as a last resort to use a material having only a limited service lifetime, with replacement planned at regular intervals. This approach is similar to that sometimes used in laboratories handling radioactive materials, where the possibility of contamination is quite high; cheap and easily replaceable materials of construction are used as an alternative to costly and long drawn out decontamination procedures. In many cases, such an approach is not possible, but in a few favored instances, economy and ease of replacement may combine to make it attractive.

Eventually a decision is reached upon which the company bases its bid. If the bid is accepted, testing procedures must then be designed which should simulate as much as possible the specified enviroment in order to make sure that the equipment as finally supplied will meet the specifications. Sometimes this testing phase may begin before the company is even sure of being awarded the job. In most cases, radiation and temperature will be the two most important environmental factors. In certain cases, however, other factors become important also; a ceramic-insulated component to be used in nuclear-powered rocket testing will likely be subjected to severe shock and vibration, while rubber insulation irradiated in the presence of air undergoes greatly accelerated ageing, particularly if under stress. For our purposes, the availability of a suitable radiation environment for the testing program is the most important consideration. For those companies which do not have their own irradiation facilities there exist a number of installations which are available for public use at suitable rental charges. References (17) and (18) list the facilities presently available, together with information on type of source, flux available, and policy regarding its use. In most cases competent consultation is available to provide guidance to the user on his particular radiation problem.

Two points merit re-emphasizing. First, the importance of verifying by actual test any conclusions about the behavior of a material based solely on a literature survey. Second, the importance of carrying out these tests

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**A dipole is a molecule which, although electrically neutral as a whole, is unsymmetrical with respect to charge distribution. Such a molecule is said to be polarized. When an external electric field is applied, these polar molecules tend to line themselves up with the lines of force of the applied field in the same way that a compass needle aligns itself with the magnetic field of the earth.*

nder conditions which simulate the *tal* environment. All too often ex-nsive data on the radiation stability a certain material may be avail-le—but at different temperatures. ·metimes the temperature at which e irradiation was carried out is ›t even given; a guess at room tem-erature is often made, but this is mewhat risky, since absorption of ıergy from the radiation in both e sample itself as well as in sur-unding materials may cause an ap-eciable rise in ambient tempera-re. Thus, even though data on the diation stability of a particular ma-rial may be available, further test-g will be necessary if other envi-nmental factors differ appreciably.

Summarizing what has been said bout insulators, we see that the be-ıvior of electrical insulation in a diation field must be considered om two viewpoints: (a) temporary ıenomena observed during irradia-on, which depend largely on dose te, and (b) permanent effects which rsist after removal from the field, hich usually depend on total dose. oth organic and ceramic type ma-rials experience increased con-ıctivity and current leakage when posed to radiation; this effect in eneral tends to disappear upon re-oval from the field. Permanent dam-ge is much more serious in the case organics than it is with ceramics. he permanent radiation - induced ıanges which take place in organics e chemical in nature, are irreversi-e, and can affect very drastically the operties of the material. Elevated mperatures accelerate the deteriora-on of organics. Damage to ceramics owever, is structural, rather than ıemical; furthermore, this damage n very often be annealed out at evated temperatures.

The effects of other environmental ctors which affect the insulator dur-g its specific application must be nsidered simultaneously with radia-on. Temperature, humidity, and the esence of surrounding gases are the ost important of these factors. Any ıal evaluation as to the suitability a proposed insulator for service in radiation field must be made under e same environmental conditions that the material will experience during service.

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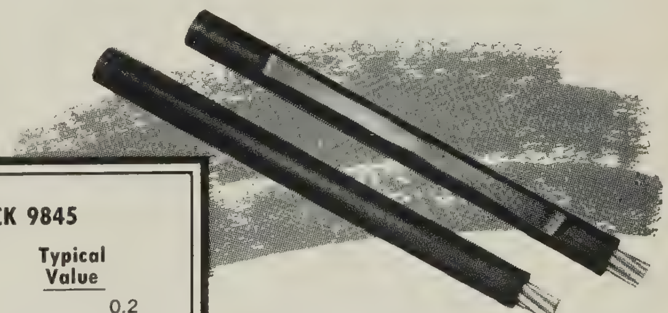

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Melt Index @ 44 psi (gms/10 min)	D 1238	0.2
Density	D 1505	0.957
Tensile Strength, psi	D 412	3400
Per Cent Elongation	D 412	250
Durometer Hardness, Shore Type "D"	D 676	58
Brittleness Temp., °C.	D 746	-95
Shear Strength, psi	D 732	3000
Stiffness in Torsion, @ 23°C., psi	D 1043	100,000
Tree Wire Abrasion Test	(1)	
50% Abraded (Cycles)		800,000 ca.
100% Abraded (Cycles)		1,500,000 ca.
Environmental Stress Cracking, F_{50}, hrs.	D 1693 (2)	500
Thermal Embrittlement Resistance, hrs. @ 70°C., F_0	(3)	5000
Deformation at 110 deg. C., per cent	(4)	0
Dielectric Constant	D 1531	2.65
Dissipation Factor	D 1531	.004
Dielectric Strength, Short Time, volts/mil	D 149	580

(1) IPCEA Tree Wire Test—S1981
(2) Samples previously aged 7 days @ 70°C.
(3) Standard U/L Heat Shock Test—1/32" insulation on #14 AWG solid copper conductor wrapped around its own diameter.
(4) UCPC Method WC 75 B/3—1/32" wall on #14 AWG wire. Test terminated at 5000 hrs.

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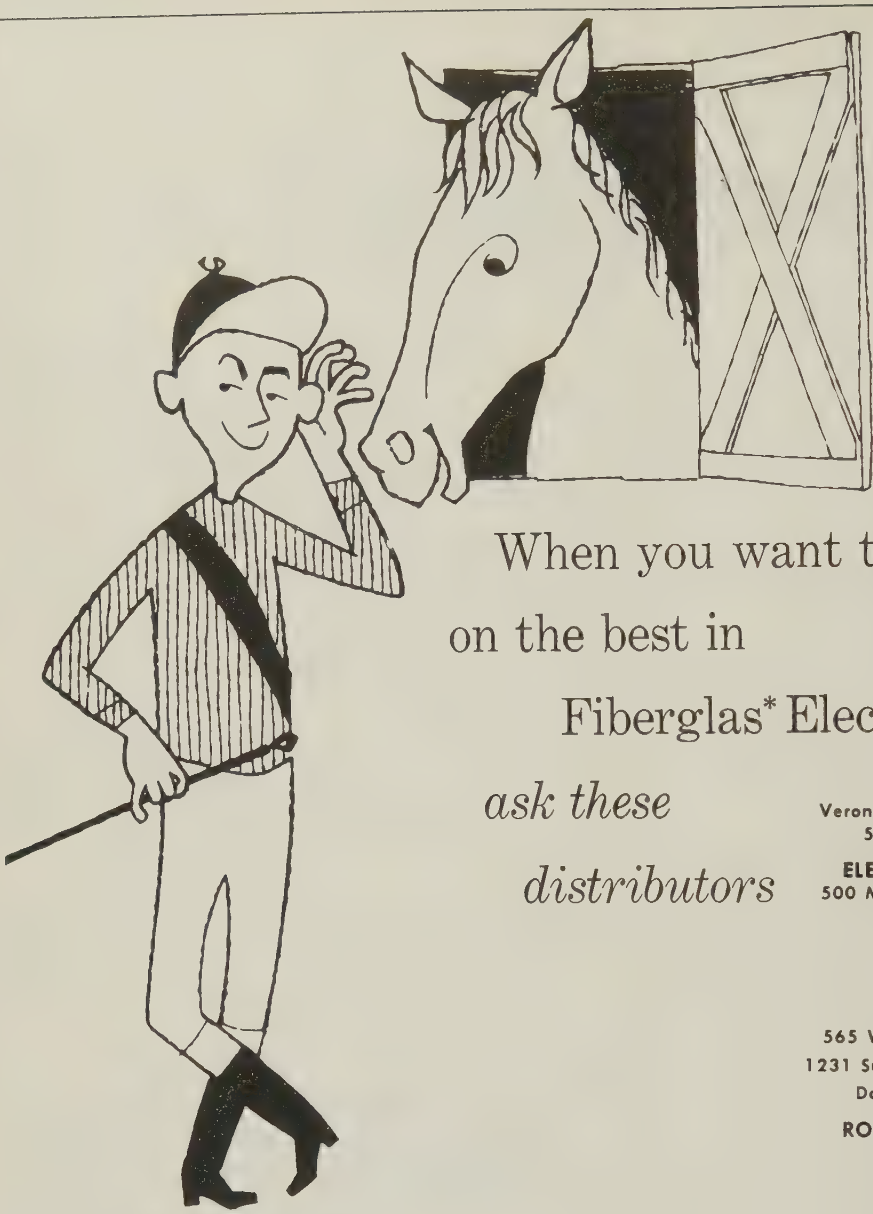


The Measurement of Thermoplasti Flow of Film Coated Magnet Wires

3y M. V. Thierry, Development Chemist, Magnet Wire Division, Essex Wire Corp., Fort Wayne, Ind.

ntroduction

When overloading of electrical quipment occurs or when a magnet vire insulation must withstand high emperatures for a long period of ime, the resistance of the insulation o thermoplastic flow is of considerable importance.

This article reviews several standard thermoplastic flow tests and describes a new thermoplastic flow test, modifications of which are currently being used by several laboratories for experimental purposes. This new method is advantageous because of the speed with which a test can be made, the similarity to application conditions, and the flexibility of the procedure. Its major disadvantage is that the thermoplastic flow values are valid only for comparative purposes.

Thermoplastic Flow Tests

Some currently used test methods that have been designed to measure the thermoplastic flow temperatures of film coated magnet wires are:

1.) The test outlined in Military Specification W-583-A consists of applying a 1000-gram load at the point of contact of two crossed wires whose axes are perpendicular to each other, and heating the assembly in an oven (which has a specified rate of temperature rise) until the insulation cuts through. To detect when the insulation has cut through, the conductors are connected to a circuit that gives an audible or visual signal. The

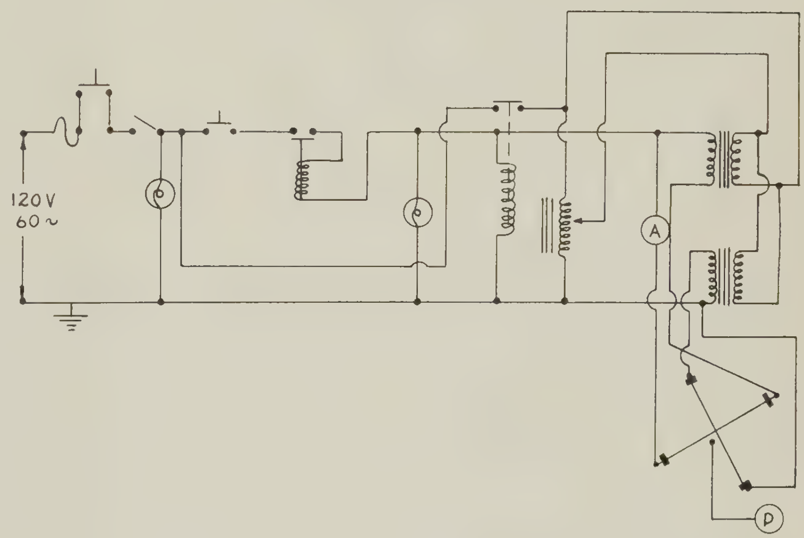


Figure 1, schematic wiring diagram for experimental thermoplastic flow tester.

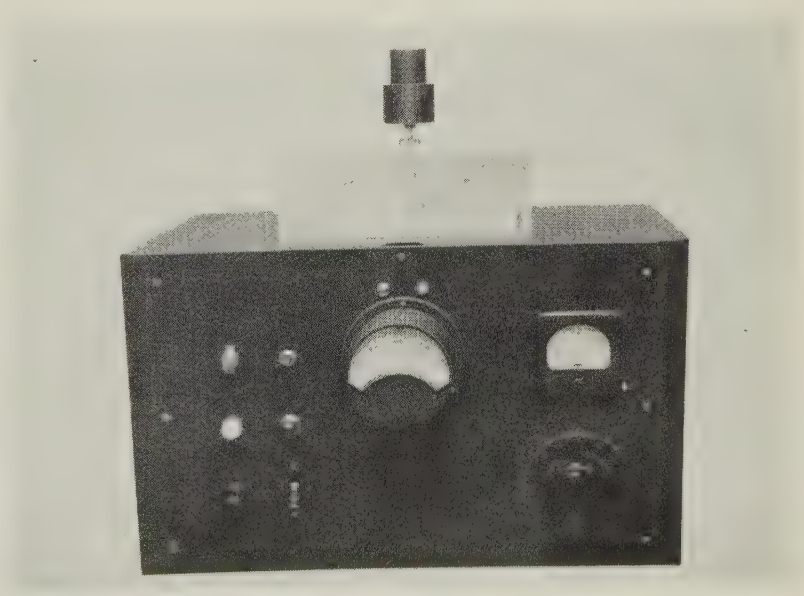
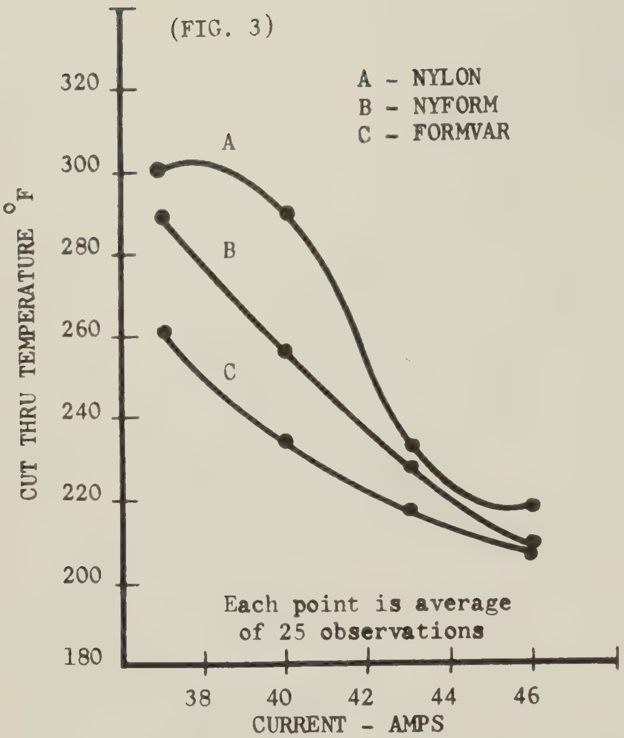
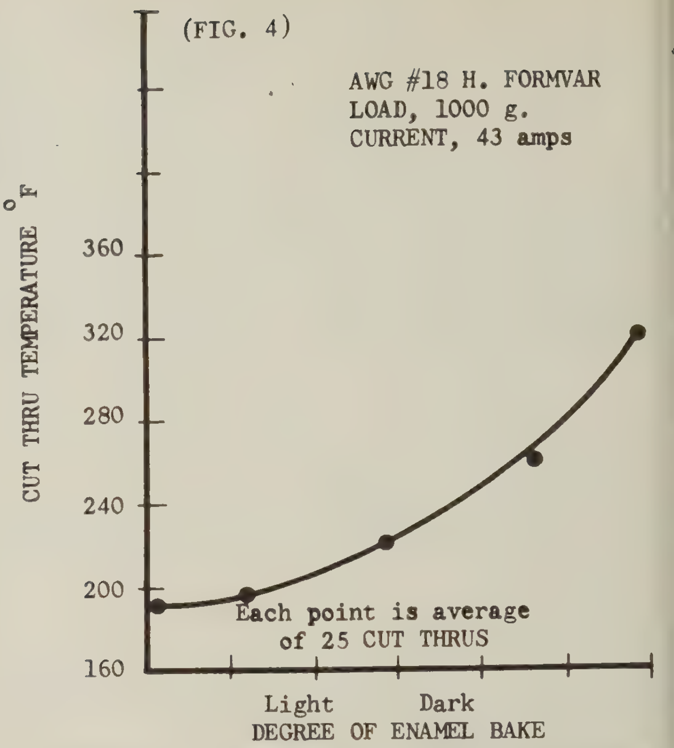


Figure 2, experimental thermoplastic flow tester.



CURRENT versus CUT THRU TEMPERATURE



DEGREE OF ENAMEL BAKE vs CUT THRU TEMPERATURE

temperature at which the thermoplastic flow takes place is determined with a thermocouple placed directly beneath a steel plate upon which the wires rest. This test is probably the most common and widely accepted thermoplastic flow test currently in use in this country.

Although this procedure is basically satisfactory, a considerable length of time is involved in making a test using the 0.5°C rate of temperature rise specified in the procedure. This limits the number of tests that can be performed in a reasonable period of time unless a large number of test fixtures are available. Hence, to establish a statistical average for a particular film type becomes impracticable.

2.) In Europe a similar test is used, as specified in the German Specification DIN 46 453. In this test a steel wire having a diameter of 1 mm is used as the top wire and a vibrator is attached to the apparatus to compensate for internal friction.

The German thermoplastic flow test, statistically speaking, may have a lower standard of deviation than the Military Specification W-583-A procedure because of the use of a vibrator. However, it still requires a considerable amount of time to complete a test.

3.) Another method that is occasionally employed is to wind a 0.5 mm gauge enameled wire 162 turns around a copper tube of specific dimensions. A constant current of 10 amps is allowed to flow through the specimen until cut through occurs. The time to cut through and the temperature of the tube are recorded.

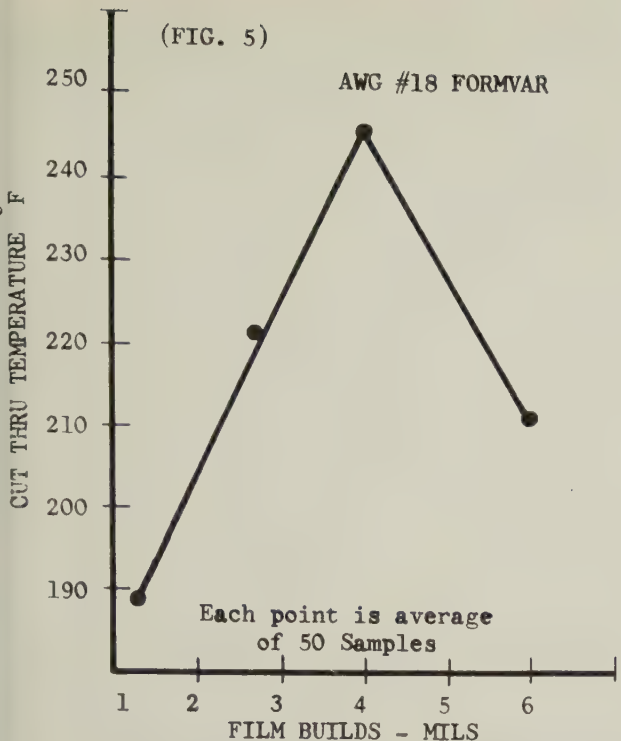
This test appears to have considerable merit because of the relatively short time in which a test can be conducted and the manner in which it simulates application conditions, i.e., heat breakdown of the insulation occurs by resistance heating of the conductor.

Although there are many other thermoplastic flow tests, as well as variations of the preceding, one particular new test method has been investigated that appears to eliminate many short-comings of the other methods.

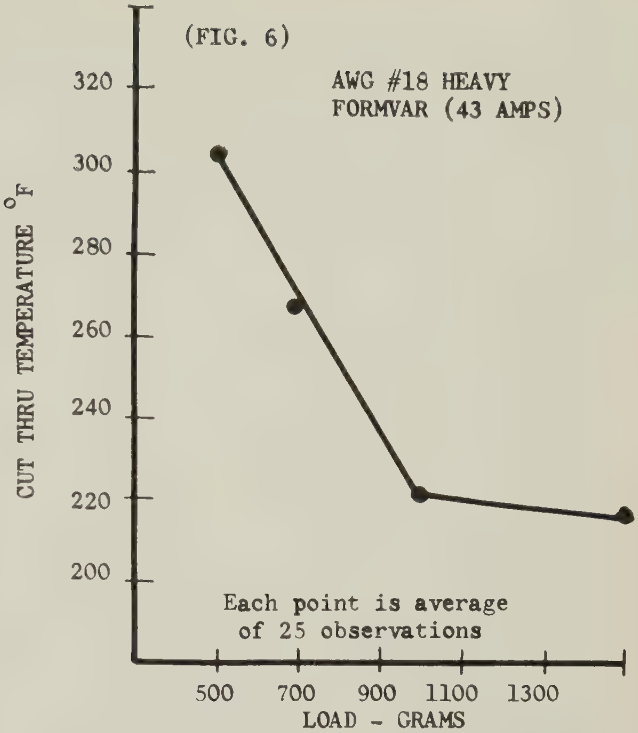
New Thermoplastic Flow Test Method

The new thermoplastic flow test method is similar to the one in the MIL W-583-A Specification in that two crossed wires (about 6″ in length) are used whose axes are perpendicular and a 1000-gram load is applied at the point of contact. However, instead of the apparatus being heated in an oven, a sufficient and equal current is applied to each of the ends of the two crossed wires to heat the conductors by resistance. The current is maintained at a constant power setting by regulating a powerstat and observing an amp meter until breakdown of the insulation occurs (about one minute). To detect cut through as soon as it occurs, a 0.5-ampere circuit breaker was wired into the circuit (figure 1) which trips as soon as the crossed wires short out. The temperature at cut through is read on a pyrometer (figure 2) which is connected to a thermocouple probe placed directly under and partially surrounding the bottom wire at its point of contact with the top wire. Each thermocouple probe has to be tailor made for a specific AWG size.

This test method is quite flexible in that many variations and modifications of the basic procedure can be



FILM BUILD vs CUT - THRU TEMPERATURE



LOAD versus CUT THROUGH TEMPERATURE

used to obtain specific information about the heat breakdown characteristics of a material.

Effect of Heating Current On Cut Through

Initially, tests were run at several different current settings and a graph (figure 3) was prepared plotting cut through temperatures versus current. This was done to determine what current setting would provide adequate differentiation of thermoplastic flow temperatures of the various magnet wire film types. It was found that the amount of current applied is of importance because at one particular current setting, one film type may exhibit a higher thermoplastic flow temperature than some other film type. But, at a different current setting for the same materials, the same relationship may not hold, viz., nylon and Nyform.

Statistical Analysis of Data

One current selected for statistically comparing the thermoplastic flow temperatures of six different magnet wire film types was 43 amperes. The statistical analysis of the data (figures 7 thru 12) illustrates the relationship between cut through temperatures for six different magnet wire films. All wires tested were AWG #18 heavy build using a 1,000 gram load. The thermoplastic flow values are lower than those obtained by the MIL W-583-A method as some heat is dissipated into the atmosphere. Relatively speaking, the results compare favorably with results obtained by other cut through test methods, i.e., acrylics and modified polyesters cut through at much higher temperatures than the other magnet wires.

Of special interest is the shape of the various distribution curves. Most of the histograms exhibit a fairly normal distribution pattern with the exception of polyurethane. This broad distribution is difficult to explain as it is not evidenced on nylon overcoated polyurethane. One possible explanation is the fact that the polyurethane component of heavy polyurethane is about twice that of heavy nylon overcoated polyurethane in build and it has been noted on previous tests with this instrument that the standard deviation and skewness of the distribution increases as film build increases (possibly because the eccentricity of the film is more pronounced on heavier film builds). This particular area is undergoing further investigation as well as correlation of cut through temperatures with soldering temperatures for urethane type coatings.

Each of the histograms are for one particular enamel formulation and one degree of enamel bake and should not be taken as representative results. The shape of the distribution as well as the mean, and the standard deviation are dependent upon many factors in addition to film build. Some of these factors are best illustrated by the following:

Effect of Enamel Bake

Figure 4 shows degree of enamel bake versus cut through temperature for "Formvar." It can be seen from this graph that the darker the enamel bake, the higher the cut through temperature. One explanation for these results is that the low molecular weight components are eliminated and further polymerization of the basic resin takes place during additional oven cure. However, it would

not necessarily be desirable to bake the enamel more to obtain the highest thermoplastic flow values, as loss of film flexibility would occur. This test, when used in conjunction with flexibility tests, is a valuable quality control aid in obtaining optimum enamel bake for a particular wire enamel.

Effect of Film Build

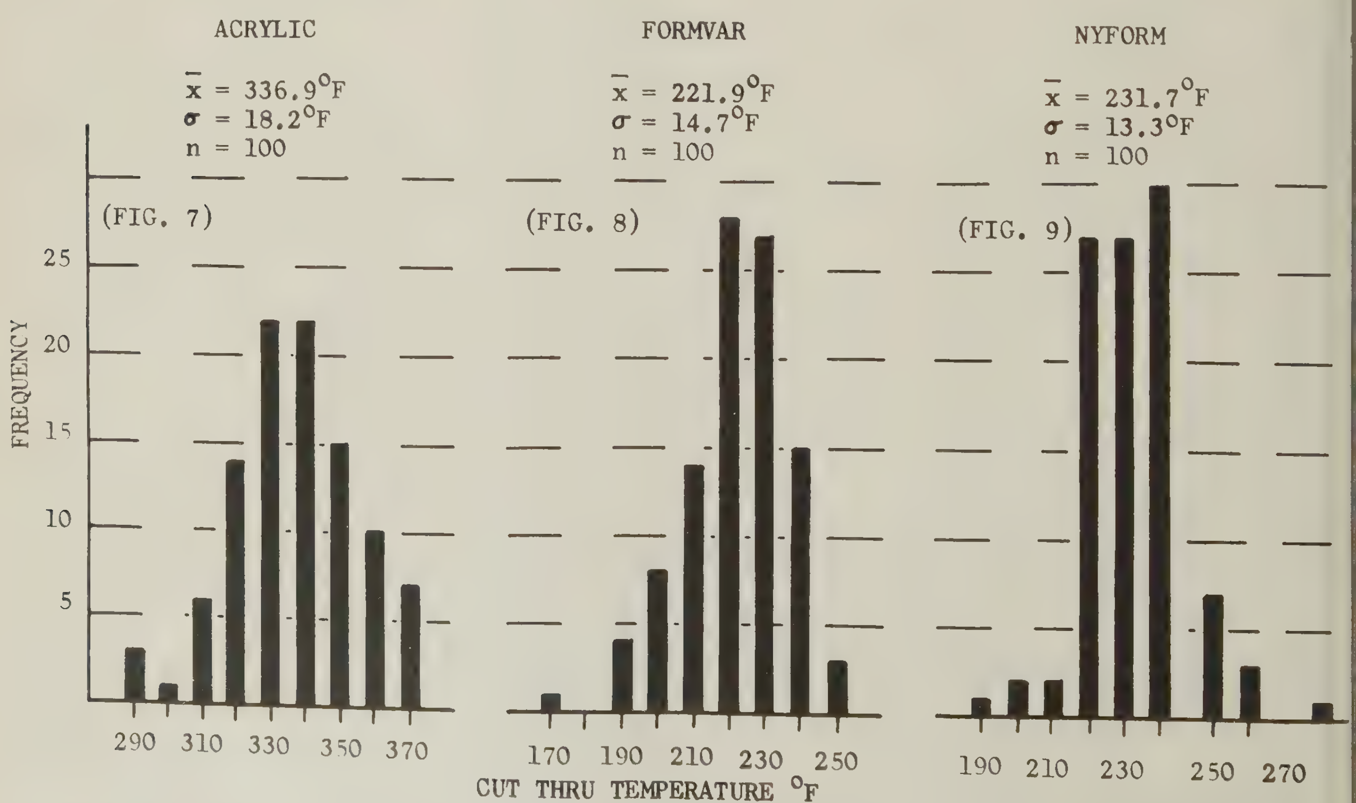
Figure 5 shows film build versus cut through temperature for four different "Formvar" builds. This graph indicates that cut through temperature does not necessarily vary directly as film build since the heaviest build "Formvar" has a lower cut through temperature than two samples of lesser build. These variations are attributed to differences in degree of enamel bake (refer to figure 4.) However, film build does have an effect on the cut through temperature as previously stated. Reference to the histograms gives some indication of how cut through temperature is affected by small variations in film build, i.e., within the manufacturing tolerances for heavy build enamels.

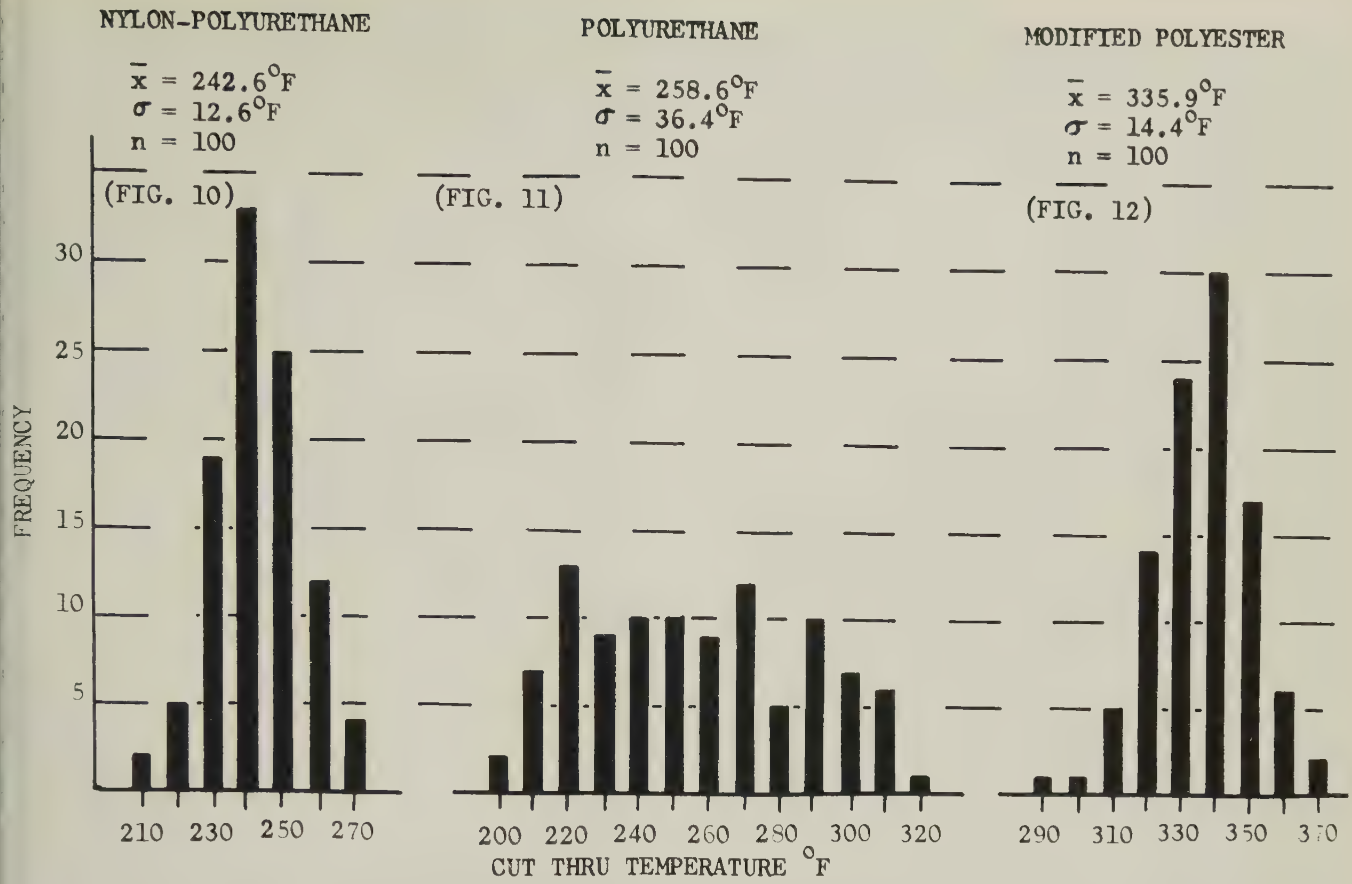
Effect of Pressure

The effect of load on cut through temperature, figure 6, illustrates that cut through temperature varies inversely as the load for "Formvar." Over the limited range of loads employed it can be seen that this factor has a pronounced effect upon the cut through temperature. This contributes to the difficulty in predicting how well a particular insulation will withstand overload, as the conditions of the winding would have some effect upon cut through. Since the quality of the winding is affected by oil, coefficient of friction of film, hardness of copper, and winding technique, the reliability of a prediction becomes questionable when based solely on thermoplastic flow test data.

To illustrate this, it is often thought that the material with the highest cut through temperatures will withstand the greatest amount of overload when part of a unit. However, this is an erroneous analogy. Further investigation of the heat breakdown properties of the insulation, as well as many other factors which have come to light as a result of this testing, are necessary before this can be determined. In addition to those factors previously noted, it requires knowledge of oxygen barriers, such as overcoats and varnishes; thickness of film; amount of pressure to which film is subjected; magnitude and duration of overload current; mechanical vibration; and mechanical injury to the insulation during winding.

These factors are not taken into consideration when standard cut through tests are conducted. Therefore, in order to safely make forecasts about the heat breakdown properties of the magnet wire it would be advisable to test actual units. This does not mean that standard thermoplastic flow tests are useless but merely that the results are sometimes misinterpreted. Actually the cut through test as such is valuable as a means for determining certain important, but limited, information about the enamel. For example, a magnet wire that is to be utilized at a high thermal rating such as a class F would have to have a higher thermoplastic flow temperature than a class A material if it is to withstand high temperatures for extended periods of time. Hence, thermoplastic flow temperatures are almost in direct correlation with a material's thermal classification as obtained by AIEE #57 procedure, i.e. the higher the cut through temperature, the higher the thermal rating at 30,000 hours life.





Inconsistencies Between Field And Laboratory Testing

The following example serves to further illustrate some of the apparent inconsistencies that exist between laboratory and field tests: Often times it has been stated that Nyform is better under conditions of overload than "Formvar" and that polyurethane is not as good as either. This statement of course is incongruous with cut through test results. In order to prove which was valid, locked armature field tests were conducted on units wound with these materials. The results substantiated the first statement. These differences can be explained, however, when other factors are taken into consideration. First, Nyform, with its low coefficient of friction (due to nylon overcoat), is subject to less mechanical injury during winding than "Formvar" or polyurethane; second, nylon is a thermoplastic material which retains more of a dielectric barrier than a film like "Formvar" which becomes brittle under severe heat and flakes off when subjected to mechanical vibration. But, this may only hold when nylon is used within class A limits since the polar and ionic components at higher temperatures become active to carry electric current and consequently, the dielectric breakdown of nylon becomes greatly reduced at elevated temperatures.

This suggests another approach to thermoplastic flow testing, e.g., apply a voltage, say, 1,000 volts to the wires and test in a similar manner as a regular cut through test. Record the time to failure as well as the temperature at failure. This would tend to simulate end use application conditions more closely than cut through temperature alone, since it would take into consideration the dielectric effect on the insulation. However, there would still remain many variables to be considered.

Summary

Methods for the measurement of thermoplastic flow of film coated magnet wires have been outlined. One particular test method was investigated and analyzed statistically. The data served to illustrate some of the interesting and valuable information that can be obtained from thermoplastic flow tests. It was by no means intended to be an exhaustive investigation. Its main function was an initial investigation to bring to light possible new approaches for the testing and subsequent correlation of results with end use application.

Many pertinent questions remain to be answered concerning the heat breakdown characteristics of an enamel. It is believed many of these can be answered, as well as new observations brought to light, through further expansion and development of this or similar test procedures.

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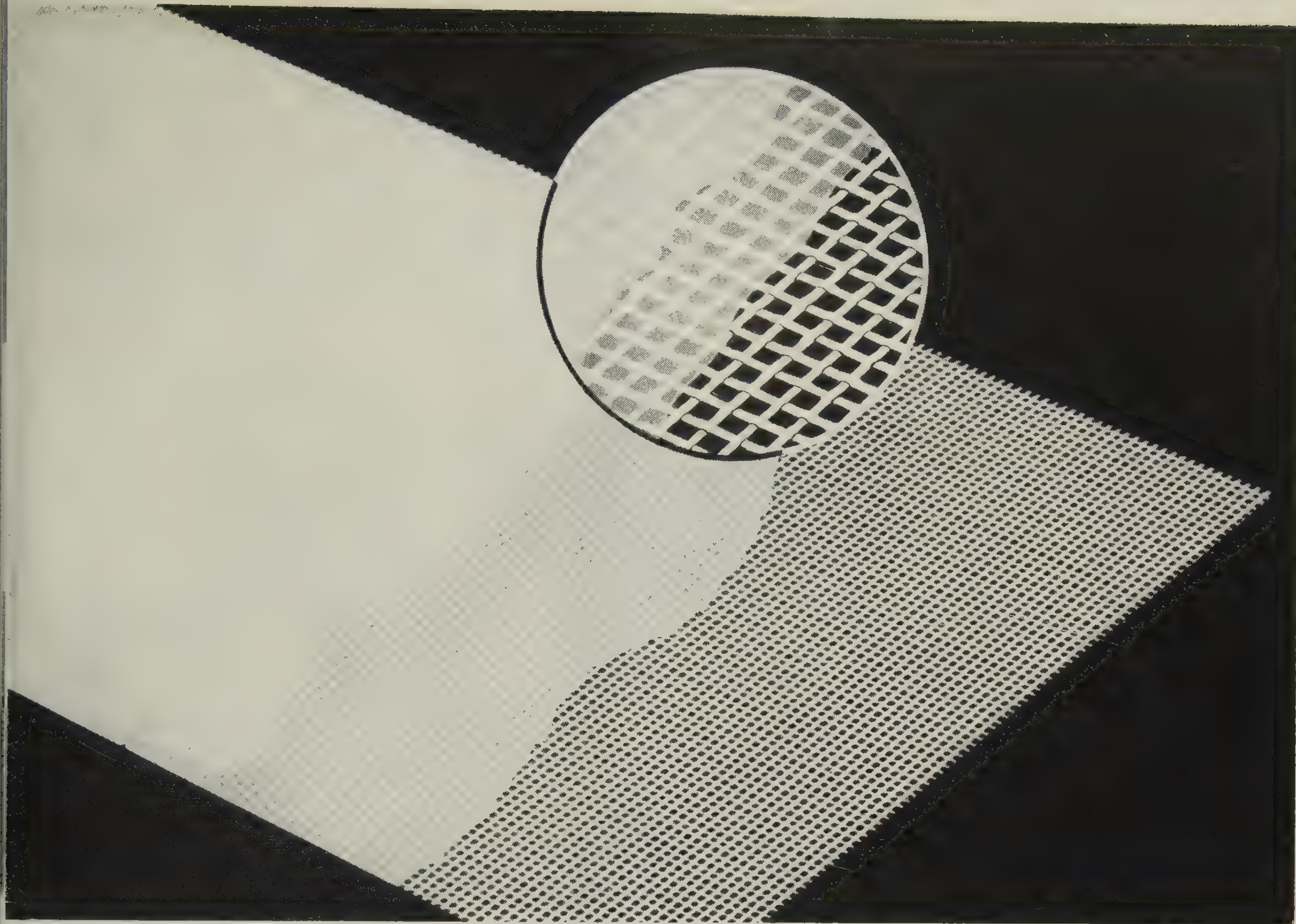
Acknowledgments

The author wishes to thank R. H. Miller and R. O. Weisz of the Essex Wire Corp. for their assistance and suggestions in conducting these tests.



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Insulation Tests

Coefficient of Thermal Conductivity

These articles, by H. K. Graves, Supervisor, Electrical Insulation Section, Materials Laboratory, New York Naval Shipyard, are designed to explain the purpose, reasons, operation, meaning, and interpretation of results, etc., behind various tests for electrical insulation. Mr. Graves is also chairman of Committee D-9 on Electrical Insulating Materials of the American Society for Testing Materials.

In evaluating polymerizable embedding compounds for electrical insulation, thermal conductivity must be considered as an important characteristic, since one of the main uses for these materials is for embedding electronic circuits or components such as transformers. In most cases, heat is generated internally in operation and has to be conducted to the surface of the embedded unit so that it can be dissipated without building up excessive and damaging internal temperatures. The thermal conductivities of these materials are poorer than metals but considerably better than thermal insulating materials—within this conductivity range a test method was sought which would give reasonably good accuracy with a minimum of equipment and complication of procedure.

The method adopted uses very simple equipment, requires a minimum of skill, and produces accurate results, while consuming a minimum of time for adjustment and operation. Results between laboratories can be reproduced to well within 10% and comparisons with the well-known guarded hot plate method for thermal insulation show no significant difference in coefficient of thermal conductivity for several embedding compounds. It would appear that the method should be more widely used for plastic materials but its very simplicity apparently makes its accuracy suspect.

The method is a part of the new ASTM Designation D1674-59T, Tentative Methods of Testing Polymerizable Embedding Compounds used for Electrical Insulation. Conductivity of an embedding compound is defined as the rate of heat flow under steady conditions, through unit area of unit thickness per degree C, using a ⅛-inch thick cast sheet of the compound.

The apparatus consists of two main parts. The heat source is simply a vessel which holds boiling water and is normally copper with heat-insulated sides and a flat, smooth-ground, nickel-plated base. The receiver is a copper plug, also flat and ground smooth on top with sides and bottom which are thermally well insulated. A copper-constantin thermocouple is embedded in the copper base of the source and a second is likewise embedded in the copper plug of the receiver. The temperature measuring instrument is connected by copper wire to the copper leads from the two thermocouples and the two constantin leads are connected together to read difference on a galvanometer, d-c milliammeter, or potentiometer. The remaining equipment, consisting of a micrometer, stop watch, and immersion heater, is available in any laboratory.

Specimens are cast sheets 3 x 3 inches, ⅛-inch thick, and flat with surfaces free of major imperfections such as ridges or cavities which would prevent good contact with the ground surfaces of the source and receiver. Thickness is measured at several points on the specimen by one of the methods of ASTM Designation D374 and readings are averaged.

To exclude small amounts of air and to considerably improve the accuracy of the method, a few drops of mineral oil are spread on one surface of the specimen. The specimen is then placed oiled side up on a bench top or other fairly good insulating surface and the source vessel is placed on top and filled with boiling water which is kept boiling with the immersion heater. The receiver is cooled to approximately —10°C by covering it with a layer of dry ice. The ice is then removed and mineral oil is spread on the receiver surface. Within a short time, the meter will reach a constant reading indicating that the specimen has been heated and reasonably steady temperature conditions have been reached.

Specimen and source are then lifted onto the receiver and a five-pound weight is placed on top to further improve contact between source and specimen, and between specimen and receiver. Meter deflection is then read every two minutes until 16 readings have been taken. Generally, further readings will result in a departure from a straight line when data are plotted, since the temperature of the receiver will be high enough to start radiating excessively. Reducing the temperature of the receiver considerably below room temperature by means of the dry ice has been found to greatly improve accuracy.

The logarithms of the meter readings are plotted against time in seconds using linear graph paper. A straight line is then drawn through the points disregarding any which deviate and extending the line to both intercepts. Using these intercepts and a simple formula included in the method, the coefficient of thermal conductivity in cal cm per sec sq cm deg Cent may be readily calculated. For a given piece of equipment, several of the constants in the formula need only be calculated once and the resulting formula is further simplified to a constant multiplied by the specimen thickness and divided by slope of the line.

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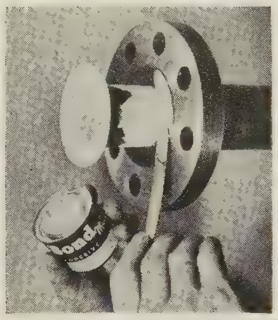

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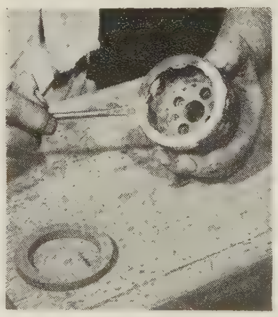
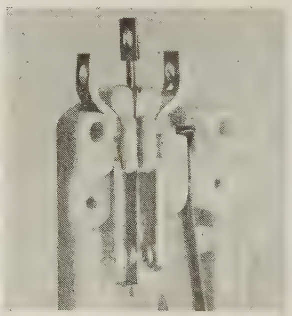
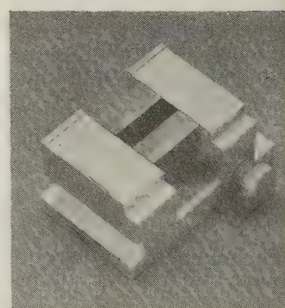

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SPE Annual Technical Conference Highlights And Reports on Insulation Papers

Technical sessions of special interest to insulation men attending the recent 16th Annual Technical Conference of the Society of Plastics Engineers in Chicago included Plastics in Electrical Insulation, Reinforced Plastics, Radiation and Missiles, and others. Reports on several papers are presented following news of society actions.

New society officers announced at the meeting are: President—George W. Martin, Holyoke Plastics Co. Inc.; 1st Vice President—Frank W. Reynolds, Endicott Plastics Research Laboratory, IBM; 2nd Vice President—Haiman S. Nathan, Atlas Plastics Inc.; Secretary—James R. Lampman, General Electric Co.; and Treasurer—Joseph B. Schmitt, Koppers Co. Inc.

The 17th Annual Technical Conference will be held at the Hotel Shoreham, Washington, D.C., January 24-27. The executive committee for the 1961 ANTEC consists of general chairman Gordon M. Kline, vice chairman (arrangements) Frank W. Reinhart, vice chairman (program) Albert Lightbody, secretary George W. Flanagan, treasurer Taylor A. Birckhead, and SPE executive secretary Thomas A. Bissell.

PAG on Electrical Insulation

At the meeting of the Professional Activities Group on Plastics in Electrical Insulation Walter A. Gammel, Sr., Automatic Process Control Inc., was re-elected chairman. Other new officers are: vice chairman—A. Zavist, General Electric Co.; and secretary—Len Buchoff, Electro Tec Corp.

Working group chairmen for the coming year are: Encapsulating—Dr. Richard Black, Westinghouse Electric Corp.; Molding and Protective Coatings—George Chadwick, Speer Carbon Co.; Equipment and Processing Machinery—John Hull, Hull-Standard Corp.; Abstracting—Dr. J. Weschler, Ciba Products Corp.; Standards—Henry Hirsch, General Precision Lab.; and Printed Wiring—Gerald Reardon, Convair Corp.

Reports on papers of interest to *Insulation* readers follow.

Effect of Humidity on Surface Resistance of Filled Epoxy Resins

By L. S. Buchoff and C. H. Botjer, Electro Tec Corp.

Epoxy resins must often be modified to produce desired physical properties. These modifications can seriously lower the electrical properties of the insulation. In components where the electrical insulation is exposed, such as printed circuits and slip rings, surface resistivity is an important consideration. Humidity affects surface resistivity almost at once. The surface condition of the plastic will greatly affect its resistance to humidity. This is particularly true in the case of laminates where the reinforcing material is bared by machining.

Test pieces were made which simulated slip rings and similar configurations. Test apparatus was used which permitted control of the temperature in the humidity test chamber to within 0.1°C of the desired temperature.

To show the effect of humidities on surface resistivity of unfilled epoxies cured with different hardeners, three of four specimens were cast of a standard liquid epichlorhydrin bisphenol resin. Number 1 was cured with aromatic amine mixture, number 2 with methyl nadic anhydride and 1% DMP-30, and number 3 with diethylene triamine. Number 4 was a high temperature novolac epoxy resin cured with the aromatic amine mixture. The aromatic amine produced castings having the highest resistivity. Methyl nadic anhydride cured epoxy had higher resistivity above 90% relative humidity than that cured with DET. From the limited tests run on the novolac epoxy it appears superior to the bisphenol type, but further testing is required.

In military acceptance tests, equipment is conditioned in cycling humidity, removed from the test chamber, and allowed to stand in a specific ambient before testing. Condensation often takes place on the plastic surface. When the part is removed from the chamber, there is a period during which water evaporates from the surface and the plastic comes to equilibrium with ambient moisture. To obtain these "drying out times," the test pieces were soaked in distilled water overnight and then put in an 80, 91, or 96% humidity container. The resistance was then read periodically until equilibrium was attained.

In a plot of surface resistivity vs. time (80% RH, 25°C) for the previously described samples, aromatic amine again gave the best results. Next, the effects of fillers were studied. All samples were cured with aromatic amines. Resistivities at relative humidities above 70% at 35°C were determined for epoxies filled with calcium carbonate, silica, calcium silicate, and mica. Concentrations of fillers were varied from 25 parts per hundred resin to 125 parts per hundred. There was no significant difference in the resistivities at different filler concentrations. "Drying out curves" for the same specimens show that whereas the calcium carbonate produced the highest equilibrium surface resistivity, it was the slowest to recover high resistivity readings.

Four epoxy-glass laminates from four different sources, and a paper-

epoxy laminate were also tested. In a study of the humidity effect on the surface resistivity for these pieces, the differences in laminates were statistically significant and represent the variations in commercially available materials. In a test of the surface resistivity vs. time in a 91% humidity ambient after the overnight water soak, the recovery rate of the glass-epoxy laminates was much slower than any of the cast resins tested.

To demonstrate the difference in drying rates in the various humidities, the time vs. resistivity curves of an epoxy-paper laminate were determined. Epoxy papers have a much lower resistance in humidities than any of the other materials tested. There is a minor difference in the recovery rates of the surface resistivity in humidities up to 91%, but at 96% it takes four times as long to reach a certain resistivity as at 91%. This condition was found in all samples tested.

Modified Alkyd Molding Compounds

By J. J. Moylan and P. D. Sullivan, Technical Service Laboratory, Plastics and Coal Chemicals Div., Allied Chemical Corp.

In certain applications requiring high retention of insulating properties under prolonged conditions of humidity and elevated temperature, the usefulness of conventional alkyds is sometimes limited because of gradual loss of insulation resistance due to resin hydrolysis. In such cases, diallyl phthalate materials such as type GDI 30 and type MDG are frequently specified because of their excellent retention properties under high humidity conditions. Recently, alkyd resins have been developed which possess outstanding resistance to hydrolysis and still maintain satisfactory cure cycles.

A plot of insulation resistance in megohms versus time in days for the conventional type MAG alkyd, two diallyl phthalate types (MDG and GDI-30), and a typical new humidity-resistant alkyd showed nearly four orders of magnitude difference between the GDI-30 material and the MAG type at the end of 30 days exposure to 95% RH at 165°F. The humidity-resistant alkyd types after four weeks exposure retain 10,000 megohms insulation resistance—which falls between the two diallyl phthalate types. At the end of seven weeks the insulation resistance is still between 7,000 and 10,000 megohms.

When short-time dielectric strength is plotted against temperature in °C, two humidity-resistant alkyds (granular PM-17 and putty PM-18) display excellent retention of dielectric strength up to 100°C, comparing very well with existing MAG and GDI-30 types.

Measurements made at a frequency of one megacycle show a relatively flat response of dielectric constant and power factor to temperature changes in the 25-125°C range for PM-17 and PM-18. Using a mold temperature of 300°F, a ⅛-inch section in type MAG will cure in approximately 16 seconds; the GDI-30 type will require approximately two minutes; and the new PM-17 and PM-18 materials require about 29 seconds.

PM-17 is a granular free-flowing powder which can be hopper fed into automatic preform presses or molding presses. Type PM-18 is furnished in soft putty-like sheets which can be extruded into ribbon preforms for encapsulating electronic sub-assemblies.

The molding pressure requirements for type PM-17 granular are in the range of 1,500 to 2,000 psi over the projected area of the mold cavity and lands, and in the range 800 to 1,500 psi for the PM-18 putty. Glass-reinforced types are not yet available.

At 60°F, the putty type has a storage life of approximately six months and the granular type approximately ten months. At 90°F, the putty type has a storage life of approximately two months and the granular type approximately three months.

The unique combination of properties offered by these compounds should be of interest in many fields of electrical insulation. Typical expected applications are encapsulated electronic components, terminal strips, connectors, and switchgear where the combination of high productive rates and exceptional properties show a basic advantage over existing materials.

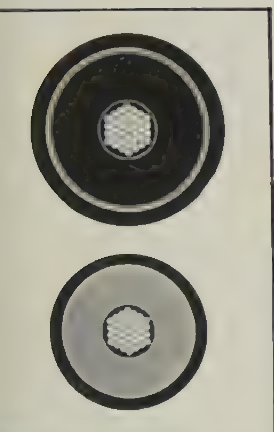
Low Loss Casting Resins

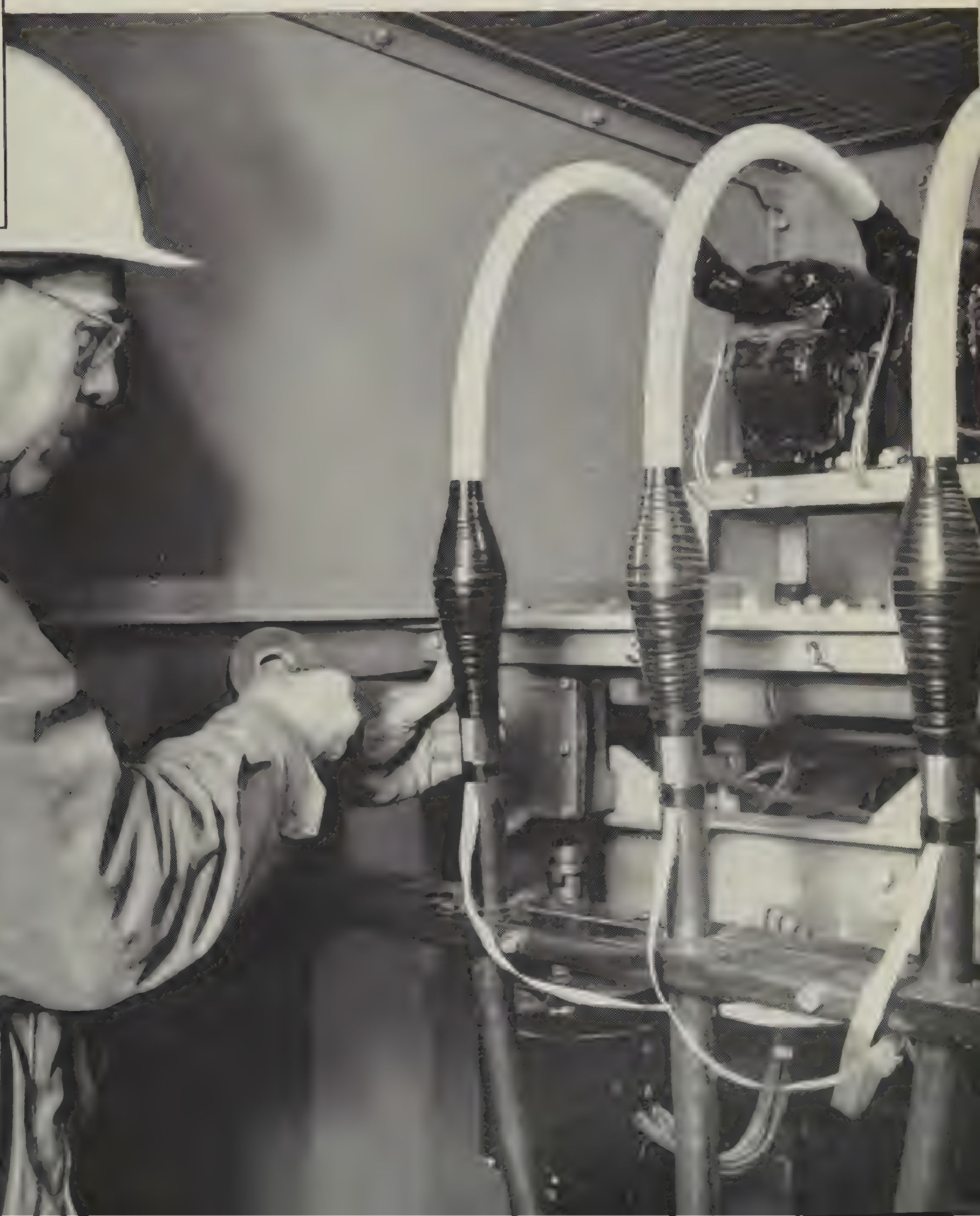
By W. R. Cuming, Emerson & Cuming Inc.

When an electronic circuit is embedded in a casting resin, electrical function is modified as opposed to operation in air. This is primarily due to the fact that a material of, say, dielectric constant 3.0 is substituted for air of dielectric constant 1.0. The electrical engineer would say that the distributed capacitance of the circuit has been increased by a factor of 3. This usually has an adverse effect on operation. In addition, the casting resin will introduce additional loss into the system.

Air is essentially lossless. The ideal casting resin would have the dielectric properties of air, yet be rugged, moisture impervious, and physically sound. Low loss casting resins become more important at the higher frequencies. There are a limited number of resins which are of low electrical loss and which can be polymerized in place. To qualify, the resin must be non-polar. Almost all of the commercially available resins which qualify are hydrocarbons. Certain monomers and prepolymers which can be used include styrene; divinyl benzene; vinyl toluene; butadiene (prepolymer); styrene-butadiene (prepolymer); N-vinyl carbazole; and 2, 5—dichlorostyrene. A casting resin formulation would use one or more of these materials in combination with diluents, modifiers, and fillers. The additives must be of low loss and be compatible with the base resin. Diluents and modifiers which are useful are hydrogenated terphenyl, chlorinated biphenyl, polyisobutylene, mineral oil, paraffin wax, microcrystalline wax, and napthalene. Fillers include silica; alumina; hollow glass microspheres; polystyrene; poly 2, 5—dichlorostyrene; polyethylene; polytetrafluoroethylene; polyvinyl carbazole; and styrene divinyl benzene copolymer. Note that in the list of fillers, polymerized resins of various types are included. These are used in finely divided form. An excellent filler to use in a monomer is the chemically identical polymer. This assures a completely homogeneous end product.

In general, the aliphatic hydrocar-





bons have lower dielectric constants than the aromatic hydrocarbons. Dielectric constant is practically constant with frequency. It should be emphasized that low dissipation factor is achieved only when resins are pure. Traces of moisture or other polar compounds are extremely detrimental. Drying of all constituents prior to formulation is important. Liquids must be dried by suspending a finely divided desiccant in them for an extended time and then filtering. Fillers should be oven dried. During subsequent use, all containers should be predried; the mold and items to be embedded must be dry. Catalyst concentrations should be kept to a minimum. Removal of polymerization inhibitor from monomers is helpful, but not mandatory.

In preparing a low loss casting resin, it is highly desirable to use fillers. They reduce shrinkage during cure, act as reinforcement, relieve strains, and may lower thermal expansion coefficient of the cured material. It is desirable that the bond between the resin and filler particle be good. This will improve moisture resistance by preventing "tunnelling" at the filler-resin interface. Thus, polyethylene and polytetrafluoroethylene filler particles should be specially treated so that the polymerized resin will adhere. Treatment must be controlled carefully so that excessive contaminant is not introduced to the formulation. Modifications of the standard chemical treatments have been used with success. In instances where the filler particle will dissolve (even though slightly) in the resin, the bond, of course, is excellent.

Hollow glass microspheres in bulk resemble finely divided sand. Each particle is a perfect hole-free bubble. Size ranges from 30 to 300 microns. This material is made in several grades. For use as a filler in low loss casting resins, a high silica (86%) glass particle which has been Volan treated is used. Bulk density is 9.5 lbs/cu ft; true particle density is 15.5 lbs/cu ft or 0.25 grams/cc. Use of the microspheres (30% by weight) in styrene-divinyl benzene resin reduced the dielectric constant substantially. Dissipation factor was maintained at a low value. Weight was reduced by almost 40%. Thermal expansion coefficient was much less than for the unloaded resin.

There are a number of problems with respect to low loss casting resins as opposed to conventional resins. Shrinkage during cure is usually high; it may be as high as 20% on the polymerizable component. This results in cracked or highly strained castings. Most of the resins previously listed produce rigid, brittle polymers. Fillers and other additives must be judiciously chosen to modify this characteristic. In order to improve high temperature properties, a moderate amount of cross linking is introduced. For example, the optimum amount of divinyl benzene to be used in a styrene polymerization for good all-round properties is 6%. This is determined experimentally. At concentrations above this, polymerization is almost impossible to control. Many of the low loss resins are of too low viscosity for easy pouring in a casting application. In this case, polymerization can be carried out in bulk to a viscosity of about 10,000 centipoise and then stopped; the resin is supplied to the user and polymerization continued. Cure cycles on low loss resins are usually long and complex with gradual increases in temperature. Room temperature cures are practically unheard of. Adhesion to metals, ceramics, etc. is usually poor. Special means, such as the use of primers, are necessary.

All in all, the problems are many. However, good results can be achieved. Where the ulitimate in dielectric properties of a casting resin are required, there is at present no alternative.

Characterization of Poly (Vinyl Chloride) Resins by the Conductivity of Solvent Extract

By J. B. DeCoste, Bell Telephone Laboratories Inc., and B. A. Stiratelli, B. F. Goodrich Chemical Co.

Plastics based on poly (vinyl chloride) resin have wide acceptance today as electrical insulation for wire and cable. To establish whether a resin has suitable electrical properties, it is customary to first compound it and make measurements on a molded slab. The heat sensitivity of the resin makes compounding a prerequisite to molding. This method of evaluation is time consuming and has the additional drawback of introducing compositional, as well as processing variables. A need exists for a direct method of distinguishing between electrical and nonelectrical resins prior to formulation.

An approach to this problem employing electrolytic conductive measurements on extracts of poly (vinyl chloride) resins has been investigated in ASTM Committee D-20 on Plastics. A relationship has been shown to exist between slab resistivity and extract conductivity measurements that should be useful in predicting the electrical properties of the resin per se. Four different extraction methods have been screened.

The principle involved in characterizing resins by an extract conductivity method is based on the assumption that the predominant factor determining compound electrical behavior is the ionic content of the base resin. It is further assumed that the contaminants are not a part of the polymer structure, which is covalent and inherently resistant to ionization, and that treatment of the virgin resin with a suitable nonsolvent will result in the extraction of the ionic impurities. The resulting increase in the conductivity of an extractant, such as water or isopropanol should, therefore, be a measure of the purity of the resin and form a basis for predicting compound behavior.

Possible sources of ionic impurities during the manufacture of the resin may be from equipment contamination, dispersing agents, catalysts, or the water used in the polymerization system. Also during the polymerization, some of the vinyl chloride polymer may break down, releasing a small amount of HCL which may be absorbed on the resin particle, giving rise to another source of ionic impurity.

Six poly (vinyl chloride) resins with a wide range in electrical properties were selected as the principal materials to be studied.

The extraction method that was developed by the task group is as follows. The resin is first wet with a small amount of isopropanol. A 2.0

±.0005g sample is transferred to a 250 ml flask and 5 ml of isopropanol is added and the mixture swirled to obtain a uniform slurry. Then, 100 ml of boiling water is slowly added, a watch glass placed over the mouth of the flask, and the contents boiled for 5 minutes.

The conductivity measurements on resin extracts are made with a dip cell and an a-c Wheatstone bridge. A cell having a constant of approximately 0.1 reciprocal centimeter is used. The cell consists of two platinum electrodes spaced within an insulating chamber which serves to isolate a portion of the liquid. The electrodes are coated with a deposit of spongy platinum, which by increasing the effective surface reduces the polarizing effect.

The conductivity of the extracts were measured in the same vessel in which the extract was prepared. After the resin particles have settled and the temperature is at 25°±.5°C the dip cell is immersed in the extract so that the electrodes are completely covered, and the resistance immediately measured. From this measurement, the conductivity in micromhos/cm is calculated.

The interlaboratory program undertaken to determine the correlation of slab specific resistivity with extract conductivity required the preparation and measurement of the electrical properties of compounds containing the resins to be studied. The use of slab resistivities for determining the electrical characteristics of vinyl plastics has been described. Conductivity data on extracts were examined for correlation with slab resistivities.

On the basis of the electrical measurements that were made on the experimental insulating compound, the six test resins may be classified as either high or low resistivity types. The high types giving values of the order of 10^{14} ohm cm at 50°C and the low ones values of 10^{10} ohm cm. Resins having a low conductivity value show the highest resistivity and vice versa.

The precision to be expected from any set of conductivity measurements will depend upon their magnitude and their source. At the low end of the conductivity scale, from 0-15 micromhos/cm the 95% reproducibility limits are within ±1.0 micromhos/cm for replicates from one laboratory and within ±2.0 micromhos/cm for those from more than one source. This is the range in which most measurements will be made as it encompasses the majority of electrical grade resins. Where values approach 100 micromhos/cm, as for nonelectrical grades of dispersion resins, limits of the order of ±10 micromhos/cm may be expected.

Interlaboratory tests have shown that by means of electrolytic conductivity measurements on extracts of poly (vinyl chloride) resin, it is possible to distinguish between electrical and nonelectrical grades. The resistivity of a typical vinyl insulating stock was found to decrease sharply when resins having a high extract conductivity were used. The test is rapid, requiring only conventional apparatus and fills the need for a method to screen resins prior to compounding.

AIEE Nominees Announced at Winter Meeting, Many Interesting Insulation Papers Presented

Clarence H. Linder, General Electric Co., was nominated to be president of the American Institute of Electrical Engineers at the recent Winter General Meeting in New York City. The election will be by mail vote of the members.

New directors nominated were Robert B. Gear and Charles T. Hatcher, both Consolidated Edison Co., and Cullen T. Pearce, Westinghouse Electric Corp. W. R. Clark, Leeds & Northrup Co., was nominated to be treasurer.

Highlighting the meeting for insulation men were technical sessions on electronics, solid and liquid dielectrics, radiation effects on insulation, insulators and radio influence, insulated conductors, and corona effects. Reports on some of the papers follow.

Insulation System for Naval Shipboard Motors Intermittently Submersed

By C. B. Hackney, Development Laboratory, Allis-Chalmers Mfg. Co., and H. P. Walker, Electrical Branch, Bureau of Ships, Navy Dept.

This paper discussed the development and testing of a waterproof insulation system applied to an a-c stator winding in a dripproof enclosure. The many aspects of the motor moisture problem were considered. It was established that the insulation system should withstand all moisture conditions encountered in shipboard service; namely, condensate from the air, condensate resulting from steam leaks, salt water spray, splash or flooding, and salt water submergence.

The motors used for demonstrating the effectiveness of the insulation system were to be in accordance with Military Specification MIL-M-17060A for integral horsepower a-c motors having the following characteristics: Enclosure: Protected, dripproof. Rating: 3 HP, 440V, a-c, 60 cycle, 1800 rpm, 3 phase. Insulation: Class B. Characteristic: Squirrel cage induction.

The developed insulation system was to be such that the motor would normally operate at rated horsepower in air without exceeding the temperature limits for the insulation system used and also operate at rated load while immersed in sea water without insulation failure or excessive corrosion.

Two design approaches were made under this development. The first approach—all the insulation applied to the conductor—was abandoned early in the development due to the nonavailability of a pin-hole free conductor insulation for class B (130°C) service and having the desired wall thickness of approximately 0.004 inches. The second approach was to use standard coil construction procedures with complete encapsulation of the windings. It was found by trial and error that many of the commercially used coil construction materials were not suitable. The following materials were found to be successful in providing a motor which operated a minimum of 500 hours when submerged in salt water: *Magnet wire:* Heavy polyester. *Ground insulation:* 3 ply, polyester mat—polyester film—polyester mat, epoxy bonded 70% fill, 0.011″ overall thickness. *Lead wires:* Silicone rubber. *Phase insulation:* None. *Coil separator:* None. *Top Stick:* Temporary 1/16″ sticks of glass-melamine laminate used for winding and assembly—removed after stator prebake. *Escapsulant:* Flexible type epoxy resin (two component system).

As salt water submergence was considered to be the worst condition expected in service, a 500-hour operational submergence test was devised. In order to check for operation in air, a cycling period was included so that the motor would operate 100 hours in salt water followed by 64 hours in air. The motor would then be cycled until failure occurred.

It was necessary to develop special techniques in the application of the insulation system to the stator. First, the stator core was treated to prevent leakage of water between the punchings. Next, the bond between the epoxy and steel could not be relied upon to give a watertight seal; therefore, the insulation system had to be made integral within itself, floating, so to speak, in the stator with a continuous envelope of epoxy surrounding all parts of the winding. In order to eliminate voids and entrapped air in the casting, a vacuum impregnation cycle was used. The leads were sealed at the connection end of the stator as well as at the terminal box by using epoxy resin. The stator encapsulant was retained and positioned by the use of steel molds for the end turns and a plug mold for the stator bore.

Results of the tests show that vacuum impregnated epoxy encapsulated stator windings in dripproof motor frames can withstand the specified conditions of moisture encountered in Naval shipboard service.

A New Technique for Improving Electrical and Physical Properties Of Inorganic Insulation

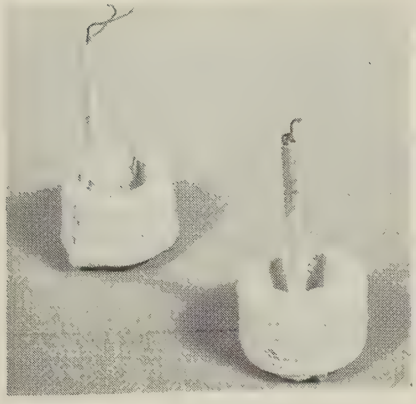
By C. H. Vondracek, E. J. Croop, and J. D. Merry, Westinghouse Electric Corp.

Many limitations still remain in the present use of inorganic insulation materials. At high relative humidity, insulation resistance is marginal for rigid military specifications and salt spray tests have produced a very detrimental reduction in insulation resistance. The mechanical shock and impact resistance still remain quite low. The thermal shock and vibration resistance of the inorganic materials are not always sufficient to pass the most severe of the military tests.

Vacuum impregnation of the insulation system with molten glass offers a solution to the problem of environmental protection of inorganic insulation systems. The process consists of three steps. First, coating and/or potting the inorganic insulated component. This coating must be of a specific type, porous and containing certain reactive components. Second, the unit is vacuum impregnated at high temperatures with certain glass compositions. These impregnants must be fluid at a temperature below the temperature limitations imposed by the properties of the conductor and magnetic materials. Unfortunately, these glasses do not, in general, have the required electrical properties of a good insulation at 500°C. Third, the processed unit is given a heat treatment so that the impregnant reacts with the potting compound and internal inorganic insulation. By this step, the composition of the impregnant is changed so as to improve the physical and electrical properties of the insulation system.

The various factors involved in the process were studied on small test coils. These coils were bifilar wound on a ceramic core 1″ in diameter by 1″ long with six layers of two glass-served No. 21 AWG nickel-plated copper wires. The test coils were vacuum impregnated with several water-suspended potting compounds. The potted test coils were fired to 650°C and then vacuum impregnated with molten lead oxide-boric oxide eutectic at 625°C. The turn-to-turn insulation resistance was measured on the coils before and after aging. These test coils are shown in the figure.

Test transformer coils were prepared by a procedure similar to that used to prepare small test coils. An alumina-glass composition was painted on each layer of windings to supply, internally, a material to react with the impregnant. The unmounted coils were given the following tests: 1) thermal shock by a direct transfer from 630°F to −65°F; 2) mechanical shock of 30 g's;



3) an ozone test at 0.05% concentration; 4) an altitude test to 80,000 feet; 5) a 50-hour salt spray at 20% concentration; and 6) vibration test of 20 g's for two hours.

The best impregnants evaluated to date are the lead oxide-boric oxide eutectic (88% PbO and 12% B_2O_3) and the lead oxide-bismuth trioxide eutectic (72% PbO and 28% Bi_2O_3). The lead oxide-boric oxide eutectic reaches a suitable fluidity for vacuum impregnation at 625°C while the lead oxide-bismuth trioxide reaches a suitable fluidity at 675°C. Materials such as Corning soldering glass No. 7570 can be used at 750°C although it is more viscous than is desired. The lead borosilicate glasses do not reach a low enough viscosity for vacuum impregnation even at 750°C.

The silica, alumina, or other suitable reactive materials may be applied to the electrical device winding as an interlayer coating and/or impregnated into the windings from a slurry, sol, or solution. Where small quantities are required, reactive materials may be applied to the wires before winding. The method of application depends upon the winding procedure, the physical configuration of the component, the temperature, and the electrical requirements of the insulation system.

The test coils for a transformer unit had a substantial improvement in their electrical properties and also their physical properties. Test units which had previously failed have now, after vacuum impregnation, been able to pass the required environmental tests.

A Study of Normality of Distribution Of Thermal Life Test Data

By J. L. Cantwell, General Electric Co.

A number of standard test procedures are now available for thermal evaluation of insulating materials and systems. So that the results of all tests made under one of these procedures may be placed on a comparable basis, AIEE No. 1F provides standardized methods for the statistical analysis and presentation of data. The basic purpose of these test procedures is to determine the rate of thermal aging of an insulating material or system as a function of temperature and thus to be able to predict its expected life at operating temperatures from data obtained from accelerated tests at higher temperatures.

The ability to make these predictions is dependent upon the assumption that thermal aging follows the Arrhenius law.

The statistical methods recommended for record purposes by AIEE No. 1F apply the least-squares method of linear regression to data obtained from accelerated life tests to determine the "best fitting" straight line relating Y to X. The line so obtained is considered to be the best estimate of the logarithmic average of life as a function of temperature. As such, it may, by judicious extrapolation, be used to predict the probable life of the insulation at temperatures below those used in the tests.

The least-square method of linear regression is based on the assumption that the deviations in Y about the regression line are normally distributed and that the standard deviation of their distribution is independent of X. Therefore, for convenience in using the method, and in the absence of evidence to the contrary, it seems reasonable to assume that the Y-deviations are normally distributed, or in other words that the original life data are log-normally distributed. This assumption has been questioned in some quarters.

Data were obtained on 511 usable samples, containing a total of 5408 observations.

As most of the samples were of small size (10 or less), they were not suitable for the chi-square test or similar tests of the significance of departure from an assumed distribution. The within-sample coefficients of skew and kurtosis were used as measures of departure from normality. The coefficients were calculated for each sample, both for the original data and for the logarithmic transformation. By observation of the effect of the transformation on the absolute values of the coefficients, qualitative conclusions were drawn concerning its effect on normality of distribution.

Of the 511 samples, three were reasonably large (size 99 or 100). Chi-square tests were made on these samples, in both original and logarithmic forms, to determine the significance of departures from normality.

The results of this study indicate that a logarithmic transformation may improve the normality of distribution of thermal life test data in some cases and worsen it in others, with no strong evidence that either effect is predominant. It is concluded, therefore, that the validity of statistical analyses based on such data is not materially changed by the logarithmic transformation.

Radiation Effects on Electronic Components

By E. R. Pfaff, Admiral Corp.

Among the components tested were insulated wires, resistors, capacitors, electron tubes, semiconductor diodes, quartz-crystals, relays, transmission lines, wave guides, transformers, switches, dynamotors, and printed circuit boards. The purpose of the tests was to provide a general survey of the problem of operating standard electronic components in radiation fields.

In most of the experiments, the irradiation continued until either the components failed or a period of one week was reached. The temperature during irradiation generally varied between 50° and 100°C, depending upon the irradiation facility used, the type and amount of cooling, the reactor power, and the energy dissipation of the component under test.

Perhaps the most universally used component in electronics is copper wire covered with some form of insulation. In general, the insulation is expected to deteriorate long before the metal is affected appreciably. The study of radiation damage to wires and connecting cables is, therefore, essentially a study of insulation damage. Insulating materials in general exhibit a decrease in resistance with an increase in the intensity of the radiation field.

Polyethylene insulation is one of the better materials for use in nuclear environments. The material actually improves for a period of time before it eventually starts to deteriorate.

The insulation resistance of polyvinyl chloride insulated wire under radiation is much poorer than polyethylene insulation. There is evidence of continued deterioration of the insulation properties of the material as the integrated dose increases.

The insulation resistance of transformer windings decreased by factors ranging between three and one hundred when pre- and postirradiation insulation resistance values were compared.

Hermetically sealed transformers suffered case ruptures near the top and bottom covers and the solder seals. Case ruptures occurring in transformers utilizing wax as a potting compound were not as severe as those in the transformers containing asphalt.

It is well known that "Teflon" and similar materials used in high temperature environments are not satisfactory in nuclear environments. A study of the insulating materials used in certain high temperature transformers showed some interesting results.

Results were catastrophic in the case of "Teflon" insulated wire and mica insulated wire which were bent after being irradiated in a gamma field. The deterioration in the latter instance is due to the destruction of the bonding material since the mica is not greatly affected by the nuclear environment.

Silicone rubber sheet used for high temperature transformer construction was embrittled. Silicone rubber, used as an impregnating material for a glass cloth, loses its binding strength in a gamma field. There were similar effects in the case of a silicone rubber with a fiber glass filler. In the case of a glass cloth coated with an adhesive material, the glass cloth was not affected by the gamma radiation but the adhesive material became brittle and had a tendency to flake off.

A military type of hermetically sealed relay was subjected to an unusually high gamma dose, due to cadmium shielding that was used to remove the thermal neutrons. The insulation on the polyethylene wire was softened and discolored due to gamma heating. Most relays are not affected by reactor radiation, however, depending upon the design, the usual insulation problems present in most electronic components may become troublesome.

Many types of electron tubes functioning in operating circuits were tested during irradiation. The failure usually is related to the envelope and seal deterioration under irradiation, resulting in the loss of vacuum.

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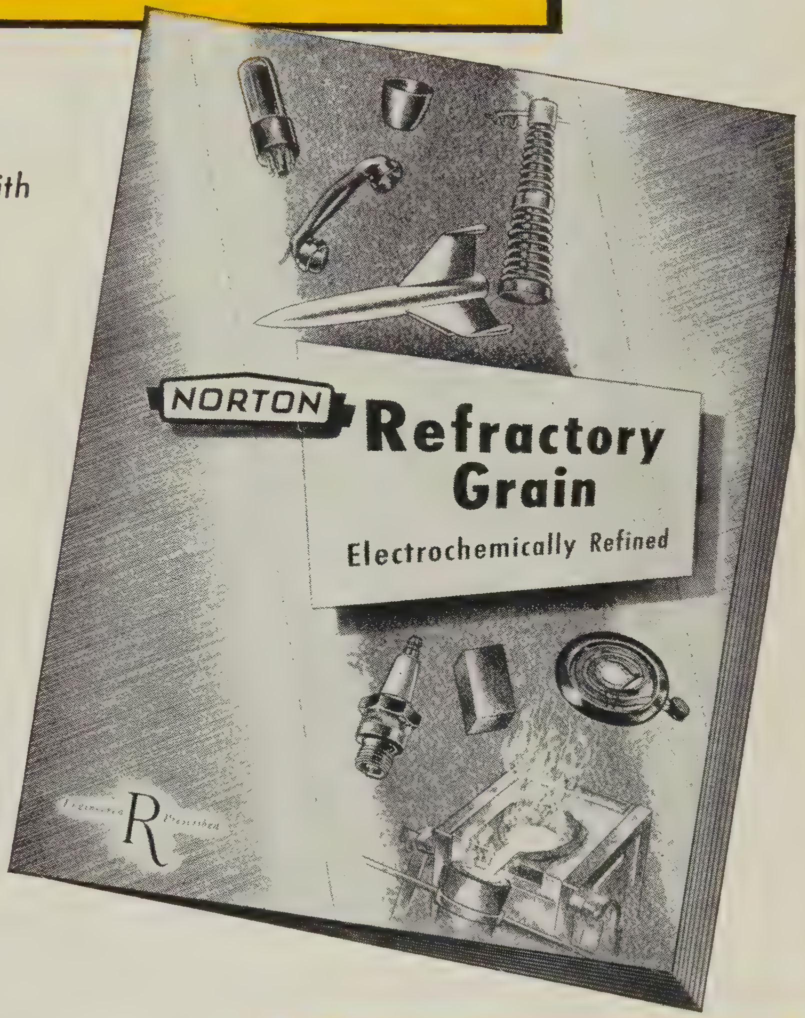

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Tubes constructed with boron free glass are usually satisfactory for use in a nuclear environment. There is sometimes slight evidence of gas evolution inside the envelope but it is seldom enough to seriously affect the performance of the tube.

The capacitance and dissipation factor of capacitors were measured during in-pile irradiation. The capacitors tested had dielectrics of mica, glass, ceramics, paper, and plastic. Except for some temperature effects, the capacitance varied only slightly with reactor power and integrated radiation dose, but the dissipation factor was much more sensitive. There was evidence of gas evolution in the oil-impregnated paper capacitors and dielectric deterioration of the plastic capacitors. Except for isolated cases, ceramic, mica, and glass dielectrics appeared to be quite radiation resistant.

Oil-impregnated paper capacitors all showed capacitance and dissipation factor changes during irradiation. In general the capacitance decreased while the dissipation factor increased, with definite differences from one manufacturer to another. One of the major problems with oil impregnated capacitors is the evolution of gas which produces rupture in hermetically sealed units. Some of the capacitance decreases are doubtlessly associated with distortion of the plates under pressure of gas evolution.

A kraft dielectric tissue commonly used for capacitors became brittle and fell apart; however, it is possible that it still may be useful if it were held immobile inside a capacitor and impregnated with a suitable liquid dielectric.

The precise testing of printed circuit boards was made impossible by the parallel leakage paths afforded by the ionized air. With the reactor at full power, the leakage current and dissipation factor became large, and the capacitance measurements were rendered uncertain by the broad null associated with the large dissipation factors. The ionization currents could be reduced by evacuating the volume, by covering the boards with proper insulating material, or by reducing the potential gradients in the air by appropriate electrostatic shielding.

All types of resistors can change in value because either the conducting material changes or the insulating cover changes. The ion field created by radiation may afford parallel conduction paths which reduce the value of the resistance by an amount which is a function of the intensity of the radiation field.

After studying the construction and the behavior of the wire-bound resistor, we have come to several conclusions. The general increase in resistance indicates that it is the wire, rather than the surrounding material which is causing the increase in resistance. The estimated total change due to temperature coefficient and order-disorder state of the wire due to fast neutron irradiation should not exceed 2%.

Composition resistors are the most unstable of all the resistor types and usually have the least rigid specifications on environmental and aging effects. In many experiments it has been impossible to separate the radiation effects from changes which normally occur with variations in humidity, temperature, and aging. It is conceivable that the radiation causes a lower resistance rearrangement of the carbon, or that the pressure of gas liberated in the phenolic shell reduces the resistance of the pellet. It is more reasonable, however, to believe that the major part of the resistance change caused by radiation is attributable to changes in the resin binder and the phenolic case. The additional leakage caused by the deterioration of these dielectrics would be more strongly in evidence in the resistors of larger nominal value.

The film type resistors usually employ a very hard, thin film which is closely bound to a core material of glass or ceramic. If any deformations or cracks of the core occur, the effect should be transferred to the film. The absence of complete failures indicated that the core material used had remained intact. The gradual increase of resistance during irradiation implied that the film was becoming less conductive, either because of a disordering of the crystalline state or because of transport of material by radiation.

Next is the effect of reactor irradiation on a group of resistors having a tin oxide coating on a Pyrex glass core. The Pyrex core contains a considerable amount of boron. The amount of damage increases as the value of the resistor is increased, the higher resistance of course requires the use of a thinner film. It is readily demonstrable that relative transport is greater for thinner films.

In respect to damage resulting from reactor irradiation on typical boro-carbon resistors, as in the case of the previous resistors, it is obvious that the damage is due to the displacement of atoms from the conducting film, and possibly a change in the crystalline structure of the conductor.

In regard to the effect of reactor irradiation on crystalline carbon deposited film type of resistors, since neither the film nor the ceramic core contains any boron, the spectacular damage associated with the two previously described resistors is not present. It is quite possible that the relatively slight change in these resistors may not be due to radiation.

The Bubble Theory for Electric Breakdown of Liquid Dielectrics

By K. C. Kao, English Electric Co. Ltd., Nelson Engineering Laboratories

Investigators have suggested that the electric breakdown of a liquid dielectric is initiated by the breakdown of gas bubbles in the liquid. So far the only evidence supporting such a suggestion is that the electric strengths of liquids have been found experimentally to be dependent on applied hydrostatic pressure. This paper discussed theoretically the possible behavior and formation of bubbles in an electrically stressed liquid dielectric based on the principle of minimum stored field energy. As a result of this theoretical investigation coupled with the experimental observation of the pressure effect on the electric strengths, it was proposed that a small bubble of gas or vapor formed in the liquid tends to elongate in the direction of the field, and that breakdown commences in this bubble when its length and the voltage along it are suitable.

On the basis of the theory an equation for predicting the electric strength of liquids was formulated. The equation is an approximate one but gives useful information regarding the factors which control the electric strength.

It has been observed that when globules of castor oil fell through electrically stressed transformer oil, they were drawn into the space between two electrodes of strong field, ultimately elongating and bridging the gap. It has also been reported that when water drops fell through an increasing electric field in air, they became elongated in the direction of the field. The same principle can be applied to explain the following phenomena which are expected to occur in an electrically stressed liquid dielectric. 1) Fibers in an electrically stressed liquid will line up in the direction of the field. 2) Particles or water drops with permittivity larger than that of the liquid will be drawn from the region of weak field into the gap region of strong field. 3) Gas or vapor bubbles, owing to their permittivity smaller than that of the liquid, will be forcibly ejected from the region of strong field into a region of weak field. 4) Bubbles of gaseous phase or globules of liquid phase in an electric field will tend to elongate in the direction of the field.

It is suggested that bubbles of sufficient size to elongate under a field of the breakdown value may be formed in liquid dielectrics by the following causes: 1) by the presence of gas bubbles, 2) by repulsion action between space charges, 3) by chemical dissociation, 4) by thermal effect due to the presence of solid impurities, and 5) by hot spots on the cathode surface.

If the foregoing suggestion of the behavior and the formation of bubbles in an electrically stressed liquid dielectric is accepted, it is possible to show the condition for electric breakdown and thus to formulate an equation for predicting electric strengths.

From the equation it can be seen that the electric strengths depend, among other things, on the surface tension and the initial size of the bubble; the latter depends on the vapor pressure of the liquid if the bubble contains both gas and liquid vapor. Thus the bubble theory can also account for the density dependence of the electric strengths of the hydrocarbon liquids, since the increase of the density of these liquids is always accompanied by the increase of surface tension and the decrease of vapor pressure. For some aliphatic hydrocarbon liquids, the results show clearly that the electric strength increases with an increase of surface tension and with a decrease of saturated vapor pressure.

A direct confirmation of the bubble theory would be to demonstrate experimentally the formation and the behavior of bubbles in the liquid when subject to a sufficiently high electric field. Present work provides only indirect evidence.

Thermal Life of Varnished Glass Cloth

By C. J. Straka and E. W. Lindsay, Westinghouse Electric Corp.

Prior to functional testing of a complete insulation system within equipment, it is

necessary to evaluate the various component materials. The insulating varnish which is a part of the insulation system is being evaluated in industry by two different methods. One method is known as the "Proof Test Procedure" and the other, "Breakdown Test Procedure." These tests can be of value only if they provide a truly adequate basis for temperature classification of varnishes.

These two test procedures for measuring thermal life have been suggested by ASTM and one of these, the proof test, has also been proposed by AIEE. The procedures differ but both employ a curved electrode test fixture which elongates the outer surface of the specimen about 2%. The elongation is intended to increase the significance of the tests with respect to service conditions.

The thermal life of an insulating varnish is estimated in the ASTM "Proof Test Procedure" by determining the logarithmic average hours required to age varnished glass fabric until failures occur when electric proof testing with a single flexing and multiple heat shock, at a level of 300 volts per mil. The "Electric Breakdown Test Procedure" measures the decay in electric strength during thermal aging at elevated temperatures. Thermal life, by this method, is defined as the number of hours required to age the specimen to reduce the electric strength to a value of 300 volts per mil after a single heat shock and a single flexing.

Both of these test procedures measure the time required for the electric strength of the varnished glass fabric to drop to a fixed endpoint. The decrease in electric strength of the insulation varnish during aging can be caused by crazing and loss in thickness due to evaporation and decomposition. The occurrence of cracking is accelerated by use of curved electrodes and hence reduces the aging time needed to reach the endpoint. The degree of heat shock to which the insulation is exposed during testing has a great effect on the amount of crazing produced. In the electric breakdown test only a minimum amount of heat shock is employed while in the proof test the specimens are exposed to a greater amount of heat shock. Hence in this respect the proof test is a much more severe test than the electric breakdown test.

Motor tests were run in order to determine if there was any correlation between the predicted thermal stability of a varnish as determined by the Breakdown Test Procedure using varnished glass cloth and as determined by the evaluation of the varnish in a complete insulation system. The tests were conducted in accordance with AIEE 510.

The breakdown test is more informative, useful, and reproducible than the proof test. There were several disadvantages encountered in using the proof test: 1) only a single failure point was measured, thus there was no knowledge of the rate of decrease in the electric strength of the varnish, 2) the results obtained using this procedure were subject to large errors due to the limited number of test values and the method used in determining the endpoint, 3) a time cycle was established prior to the start of the aging period and specimens were removed at fixed intervals of time. This sometimes led to the depletion of the test samples before the failure point was reached. This of course resulted in a waste of time since the test should have been repeated, and 4) if in the future the endpoint voltage is raised to a higher value, the data that has been taken using the proof test will be worthless.

The breakdown procedure overcame most of the disadvantages associated with the proof test in that, 1) the procedure gave the history of the decline in electric strength of the varnish during thermal aging, 2) the larger number of test values obtained permitted a higher degree of accuracy in estimating the thermal life of the varnish, 3) the procedure provided a system of holding back some of the specimens at the beginning of the aging period to be placed in the oven at a later date as needed, and 4) the procedure was very flexible as far as choice of endpoints, since the endpoint could have been changed at a later date without making any of the data obsolete.

The results obtained on the life of the insulation systems using the varnishes evaluated in the motor tests compare very favorably with the life of these varnishes as predicted by the varnished glass cloth tests using the "Electric Breakdown Procedure."

The "Electric Breakdown Procedure" can be improved by increasing the number of thermal shocks the specimen receives during the aging period. This would make the test more realistic or functional since insulation systems normally receive many thermal shocks during their life when used in electrical equipment. Another improvement would be the raising of the endpoint voltage to 400 volts per mil so that it would be at least double the breakdown voltage of the unvarnished glass cloth.

Post Irradiation Thermal and Electrical Properties of Magnet Wire Insulation

By John W. Kallander, U.S. Naval Research Laboratory

The effects of gamma irradiation on the thermal aging lives and the electric strengths of a wide range of magnet wire insulations have been determined. These experiments were conducted by exposing the insulation samples to the radiation field and then to the thermal and/or voltage fields although it is realized that the effects of exposure to radiation followed by exposure to temperature are not necessarily the same as the effects due to the simultaneous exposure of the insulation to the radiation and thermal fields.

Magnet wire specimens of 24 different combinations of insulation and varnish (in several cases, no varnish) were prepared according to AIEE Test Procedure No. 57. For 13 combinations, both the thermal lives and electric strengths following removal from the radiation field were determined, while for four combinations the thermal lives only and for seven combinations the electric strengths only were determined.

Radiation affects the thermal and electrical properties of the different classes o insulation to a widely varying degree withi the limit of radiation dosage considered The extent of the radiation damage range all the way from very little damage t polyester combinations, even at the highes dosage considered, all the way to a total or almost total, destruction of tetrafluoro ethylene combinations even at the lowes dosage considered. Modified polyester, sili cone enamel, glass served silicone, poly vinyl formal, polyvinyl formal-nylon com binations, and epoxy combinations all giv intermediate results.

Some radiation effects are dependen upon both the dose rate and dosage o irradiation. More extensive tests on poly vinyl formal have shown the dependence o the thermal life versus dosage character istics on the dose rate for the unvarnishe combination but were inconclusive for t varnished combinations.

It is believed that some of the mechan isms of radiation damage affect the therma life but not the electric strength; con versely, some mechanisms affect the elec tric strength but not the thermal life whil still others affect both the electric strengt and the thermal life but to varying degrees A comparison of the thermal life and elec tric strength changes of the different com binations should thus show a correlatio but not a functional relationship betwee the electric strength and thermal lif changes of such combination.

Experience in thermal aging has ind cated that failures, by and large, resu from mechanical degradation of the in sulating material whether it be film c sheet material in phase or ground. Becaus of this interrelationship, it is reasonabl to expect that, in radiation degradatio studies, the changes in thermal aging an electric strength characteristics will to certain extent correspond to the change in the mechanical properties of the ma terial.

Study of Thermal Deterioration of Enameled Wires by Mass-Spectrometer Method

By Y. Saito and T. Hino, The Tokyo Institute of Technology

The thermal deterioration of enamele wires insulated with polyvinyl formal, pol uretan, or polyester was investigated wit a mass-spectrometer in order to ascertai the merit of the method and also to obtai actual data on the wires. The results ol tained were summarized as follows: 1) mass-spectrometer can be effectively ap plied for the purpose of evaluating therma deterioration of enamelled wires near th working temperature. 2) The thermally de composed gases are CO, CO_2, and H_2O fo the most part, but a small quantity c formaldehyde (H-CHO) is detected in th gases generated from formal wires. 3) Th mechanisms of thermal deterioration of th samples have been clarified to some exter by examining the thermally generate gases. 4) Gas generation is increased in a oxygen atmosphere compared to a vacuum and so the actual thermal life is shorter i air than in a vacuum. 5) The relation b tween log ($CO + CO_2$) and $1/T$ is ger erally linear, but if a sample is heated i

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oxygen the line breaks into two parts having different activation energies. The values are 21 kcal/mol at higher temperatures and 32 kcal/mol at lower temperatures. It is indicated from the result that the mechanism of the thermal deterioration changes with the temperature. 6) The mass-spectrometer method gives us the same results as the weighing method. 7) The inclination of the line showing the relation between log $[1/(CO + CO_2)]$ and $1/T$ obtained by the mass-spectrometer method coincides with the inclination of the line between log (life) and $1/T$ obtained by the actual thermal life tests. 8) Thermal life of the enamelled wire may be easily estimated from the result obtained by the mass-spectrometer method. 9) It is understood that the relation between log (life) and $1/T$ is not always a straight line. Therefore, if we want to determine the thermal life of a material by the accelerating test, the deterioration mechanism must be examined prior to the actual themal life test.

Ultra High Temperature (500°C) Electronic Transformers—Design Considerations

By J. F. Rippin Jr., H. B. Harms, and G. Walters, General Electric Co.

Development activity was concentrated to the extent that the transformer electrical ratings were selected for 400 cycles per second frequency and a maximum of 1500 volts rms and 1 kva output. The goal for the operating life was 1000 hours. The environmental objectives included the major ones of 500°C temperature, intense nuclear radiation (up to 10^{12} fast neutrons and gamma photons/cm^2/sec.) and air density corresponding to 100,000 feet altitude; and the mechanical ones such as 50G shock, 15G vibration up to 2000 cycles per second and resistance to thermal cycling and moisture. These were to be withstood separately or in such combinations as high ambient temperature with nuclear radiation, shock, and vibration.

The basic philosophy of the development work was to use tests and studies of individual materials for preliminary screening and accumulation of performance data. Coordinating these with a compatible mechanical arrangement, complete units were then built from the most promising individual materials and retested under conditions of high temperature, nuclear radiation, and other environments.

Work was directed toward the eventual construction of transformers and inductors using layer-wound coils assembled on the center leg of an E-I lamination core configuration. This goal required investigating magnetic materials for the core, conductor materials and insulation for the wire, spool materials for the winding forms, sheet insulation to separate the layers of the coils, potting materials and impregnants, terminal design and spacing, protective schemes, and materials and processes for making electrical joints.

Flexible sheet insulation is used in transformer coils to help support the windings mechanically and to provide electrical insulation between layers. Of the several materials evaluated, the mica papers performed the best, with phlogopite mica showing less decrease in flexibility and less increase in thickness than the muscovite mica. Based on a sampling of 10 specimens, the insulation resistance was observed to decrease by a factor of 10^3 over the temperature range 300°C to 600°C. A 1000-hour aging period had a small adverse effect. Drops in dielectric strength of about 25% were attributable to either temperature or aging.

Results showed glass-served silver wire to have the best all-around performance. Anodized aluminum displayed outstanding electrical properties and thermal stability and had the added advantage of a very thin film build. However, processing and application problems with the base metal require solution before it will become useful at 500°C. Insulation resistance decreased by approximately a 10^4 factor and was not significantly affected by aging time. Dielectric strength decreased for both materials up to 300°C and remained steady thereafter.

Protective schemes for the core and coil centered around a metallic enclosure augmented by a filler material to occupy any air spaces within, and by an impregnant to give strength to the coil. The mechanical requirements demand that relative movement of parts within the enclosure be negligible, while the high temperature requires that this be accomplished through the use of inorganic compositions which for the most part are in the form of vitreous ceramics, refractory cements, and inorganic solutions. Extended efforts to apply a vitreous ceramic as an encapsulant, an alternate enclosing technique, failed because of the brittleness of the ceramic. A satisfactory refractory cement, however, was devised for the filler material consisting of a mixture of magnesium oxide, aluminum oxide, and aluminum phosphate solution. Its brick-like structure gives rigid support to the core and coil. Trials with aluminum phosphate alone suggested its service ability as a coil impregnant when applied under vacuum-pressure cycling. It imparts strength and rigidity to the coil but does not enhance its dielectric properties.

The spacings of terminals are affected primarily by the properties of air. Air becomes a very critical dielectric when its density is decreased by 500°C temperature, 100,000 feet altitude and its particles are ionized by radiation.

Grain oriented 3¼% silicon steel is applicable for the core of power transformers, although lower flux densities may have to be used.

Radiation testing indicated that those materials that could survive a 500°C temperature could also remain essentially unaffected by a nuclear radiation environment. Radiation does, however, cause lower air breakdown voltages.

In coil temperature rise considerations, higher ambient temperatures cause increased coil losses, but these are offset by improved radiation heat transfer, leaving a possible net decrease in temperature rise.

In general, high temperatures have adverse effects on insulating, magnetic, and structural materials. Despite these, however, transformers capable of meeting the electrical and environmental goals of the development appear to be practical.

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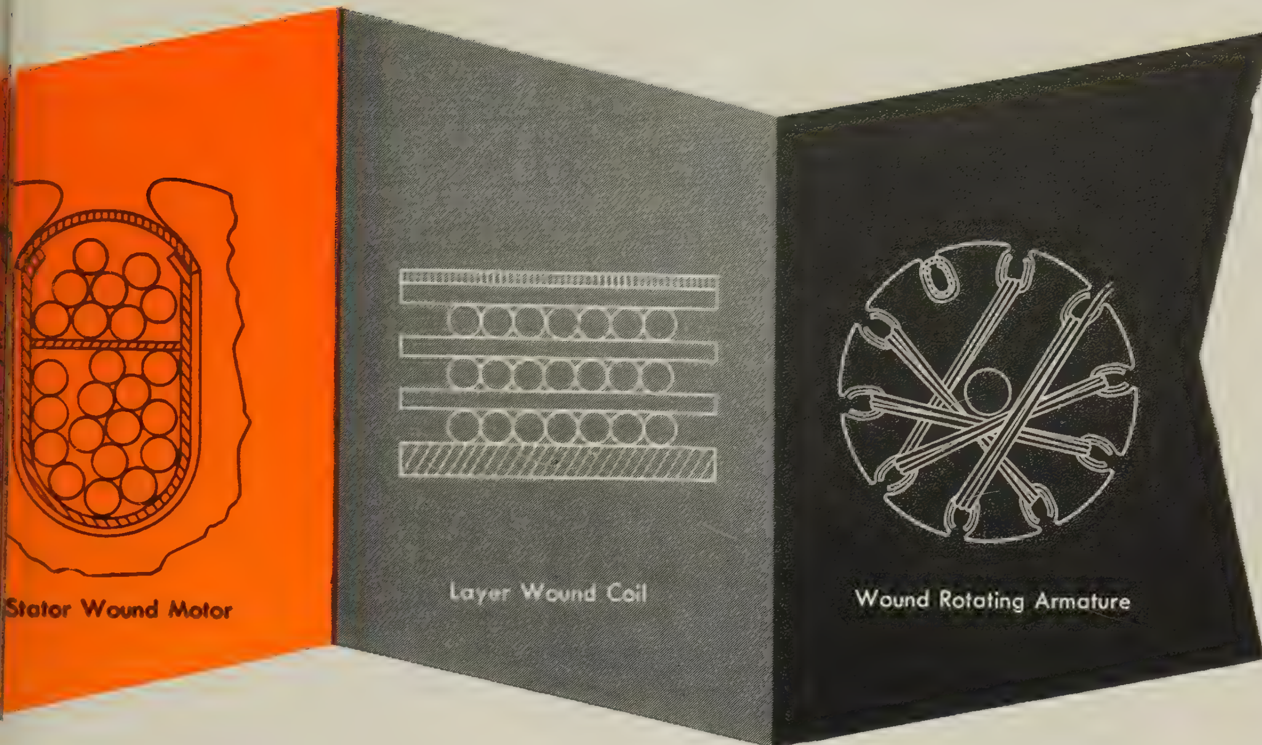

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Insulation Forum

This regular monthly feature is built around a timely question concerning the electrical insulation field. Your suggestions for future questions and participation are invited. This month's question is:

"Do you think that committees concerned with setting up electrical/electronic insulation standards and specifications should be composed primarily of insulation users or of manufacturers . . . or both equally . . . and why?"

D. L. McClenahan

Chief Electrical Engineer, Schenectady Varnish Co. Inc., Schenectady, N.Y.

"In order to set up a useful and realistic specification, the insulation user and manufacturer must cooperate. The user knows his requirements and can advise the supplier of the properties the insulation must have to meet them. The insulation manufacturer, on the other hand, knows the qualities or limitations of his product and knows within what limits his product can be manufactured.

"In this very competitive field, cost, of course, enters the picture. Specifications can be so rigid and demanding that the cost to produce a product may be excessive. Some applications may require these high standards, and the user is willing to pay the price. In any case, a mutual understanding and cooperative effort between the user and the supplier can benefit both.

"I believe that the greatest benefit to the industry lies in the area of test methods. In our own experience, we may have as many test methods as we have customers for a particular product. For example, one of the many tests which we perform is the measurement of the non-volatile portion of our products. This is of extreme importance to our customers. After all, this is really the portion which is applied to the end product. In order to meet specific customer requirements, we have over 20 different methods for determining non-volatiles (solids). Standardization within the industry to three or four methods could benefit all concerned and reduce costs.

"ASTM, AIEE, NEMA, and government agencies are all active in various phases of the insulation field. The first three are composed of men from both user and supplier companies, and are cooperating to set up good test methods and specifications. Government agencies work closely with both groups and are working toward the same end.

"Our management feels that this work is of sufficient importance to allow its technical people to participate. However, many companies are nearsighted and do not realize the results to be derived which will benefit their companies as well as the industry as a whole."

N. B. Cawthorne

Technical Director, L. Frank Markel & Sons, Norristown, Pa.

"In my opinion, committees concerned with setting up electrical/electronic insulation standards and specifications should include about an equal number of both insulation users and manufacturers. In this comment I am thinking of 'users' as the users of insulated electrical components, pieces of equipment, and complex assemblies; 'manufacturers' as the producers of the insulated components, motors, communication equipment, etc., as distinguished from manufacturers of the more or less basic raw materials such as varnishes, extrusion compounds, fibrous threads, and so on.

"Certainly, the users have the responsibility of setting up the problem, since they are directly concerned with performance and reliability of the end-product. However, a user is not likely to be as familiar with the degree of perfection that is attainable in a manufactured product as is the manufacturer of that product. Also, the manufacturer is in a position to know the relationship between performance attributes, tolerance specifications, and price. I feel that inclusion of manufacturers in these committees should have an influence toward the setting of standards and tolerances that are economically commensurate with the actual requirements of the end-product.

"I suggest that it be recognized that human frailties exist among users and manufacturers alike, and that being completely devoid of selfish interest is not a human trait. Such committees should consist of a sufficient number of people to provide a fairly accurate cross-sectional representation of knowledge and interest among both users and manufacturers of the particular products involved in a given specification.

"To complete the committee and optimize its capabilities, I suggest inclusion of a similar representation of manufacturers of the basic raw materials. Their contribution would consist of information regarding the attainable attributes of their materials, and the degree to which these properties are controlled in their manufacture.

"The setting of standards and tolerances and the writing of specifications is a highly technical subject. An obvious prerequisite of all participants in such an undertaking is technical qualification. Sound judgment relative to the influence of human skills and behavior upon the overall performance and variance in the finished product is also necessary. Of perhaps greatest importance is sincere dedication to the task of forming specifica-

tions which will control end-products that can be manufactured within the limits of performance and quality dictated by the requirements of the end-use.

"A good specification should encourage competition and development progress. It should provide realistic minimum standards of performance and quality which can serve as a basis for comparison and improvement of the products as science progresses."

E. H. Farnam

Vice President, Spruce Pine Mica Co., Spruce Pine, N. C.

"I believe that the manufacturers should shoulder the responsibility of having adequate standards in their industry which meet the needs of the majority of their users. Naturally, all of the users of any material are vitally concerned with these standards and should definitely have a part in seeing that their needs are properly met.

"In our experience, the manufacturers have a broader concept of all the requirements for their material. It is seldom that a user of mica, for instance, would use and be familiar with all the grades and qualities of mica. Usually one company will use two or three different qualities and be familiar and very conversant with these qualities; however, it would not be at all familiar with qualities either above or below what it is using. In the setting down of any material specifications, this particular user would be vitally interested in seeing that the specifications clearly cover and outline the types of material that he is using. Other customers would be likewise concerned with other qualities. For this reason, I believe it is only the manufacturer that can look at the complete picture and be able to set standards that most completely satisfy all users' requirements. This, of course, should not be arbitrary and any users of the material should definitely have a part and be called upon to give their valued opinions.

"Another difficulty is that of trying to cover 100% of the specifications that various users might desire. In the mica business there arises from time to time special applications where the user and the manufacturer

must get together and set more or less auxiliary standards. The application involved may be one in which only one company is interested and it would be difficult to have a standard such as this put on an industry-wide basis. There are always exceptions to every rule and it would be an impossibility to cover everything in a set of standards that covers an industry of manufacturers and many different industries of users."

P. R. Wilkinson

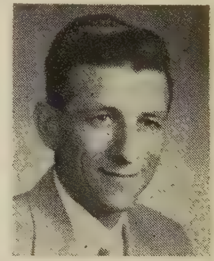
Design Engineer, Ideal Industries Inc., Sycamore, Ill.

"Standardization is in itself a paramount milestone in any median, whether it be the simplest or the most complicated piece, unit, or component. In the realm of science and industry today, or as projected in the future, it would be difficult to comprehend all applications regarding insulation in establishing standards. In reality, however, I do believe and advocate that there is a dire need for standardization of known applications for the benefit of the user, the manufacturer, and the manufacturer of associated products, too.

"The committee should be composed of representatives from the field and manufacturers as follows: Users—50%, insulation manufacturers—40%, associated manufacturers—10%. The users would consist primarily of men devoted to physical science and engineering, and above all some degree of representation of men in the field (the real users). The government should also be represented as a military specification contingent. The manufacturers of insulation would consist of men responsible for designing, developing, formulating, and producing the multitude of designs and functions of insulation. The associated manufacturers would represent those manufacturers which produce supplies, equipment, and testing apparatus to be used with insulation, or in fabricating or adapting insulation for use in the field where the design and form is the finished product, or where it is used as a piece or component in an assembly, unit, or other equipment in the field.

"Each of the three 'bodies' will have his own 'ax to grind,' but at least each will be heard and represented and shall influence the others in integrating the multitude of factors which shall arise, and a more sound, tolerable, and logical set of standards will be set up for the good of all concerned.

"The insulation standards would be ineffective or incomplete in a matter of time if any one of the bodies did not have an equal chance to establish them. Too many standards exist where the user or associated manufacturer must tolerate or work around the specified product and resort to special tooling and equipment in order to use the product where it may be specified. Then again, the user finds upon occasion that there is not one solitary associated manufacturer that makes a product to use with some standard product, and must resort to makeshift methods or 'cobble' up some standard product and use it for a function or purpose for which it is not intended at all."



Bernard Hay

Chief Engineer, Resistor Engineering Section, Dale Products, Inc., Columbus, Neb.

"The committees concerned with setting up electrical/electronic insulation standards and specifications should be equally composed of manufacturers and users. The exchange of information between representatives of both groups would prove valuable in establishing a more useful document.

"The performance requirements of these materials can best be expressed by the user. They are readily aware of the conditions under which their equipment or component parts are required to operate. Their recommendations and comments would prove extremely valuable in establishing quality assurance provisions to meet existing needs.

"In addition, comments received

from the users should prove beneficial in pointing out to the manufacturers those areas in which further development work should be conducted to meet future requirements.

"The performance level of the presently available materials are better known by the manufacturers. Their recommendations would eliminate the possibility of unrealistic test requirements being incorporated into the specification.

"Through coordinated efforts, standards and specifications may be developed which are agreeable to both industries."

P. L. Hedrick

Technical Representative, Irvington Coating Div., Minnesota Mining and Manufacturing Co., St. Paul, Minn.

"We summarize our thoughts as follows:

1. The development of product specifications should be a cooperative project between supplier and user.
2. There is a great need for the consolidation of specification preparation agencies, i.e., private companies, military services, ASTM, NEMA, SPE, AMS, etc. (the cost of duplication of effort is disheartening to a manufacturer).
3. The need for the expenditure of more high quality effort in the preparation of better test methods is just as important, if not more so, than the concentration of more effort in the preparation of product specifications. ASTM is doing a good job, but could do better if its efforts were not diluted in the direction of trying to write product specifications. It is relatively easy to prepare a good product specification if good test methods are available. The advantages of having good test methods are more readily discernable to both manufacturer and user.
4. The manufacturer of a product normally knows the characteristics of his product better than the user. The user knows the application best. Each needs the knowledge of the other to make the specification meaningful.
5. The user should not specify unrealistic requirements, which he hopes to obtain, but which are slightly above the quality level of existing products. (The lack of enforcement of requirements, or use of waivers, to permit materials to be furnished to these standards encourages supplier delinquency, and those of us who resist the temptation to go along are sometimes suspected as having ulterior motives or are classed as being uncooperative.)
6. The user should not insist on having duplicate sources of supply on new products, or on specialty items where superior quality can readily be demonstrated. (This discourages progress. On products developed under government contract, perhaps the military should have some prior rights in setting up these requirements, but on products developed by private companies the requirements should be established by mutual agreement.)
7. No product can be covered completely by a specification. (There is an element of trust, which is an invisible part of every specification.)
8. The many different product specifications now in use covering products designed for the same end use should be consolidated and shared by the military and industry. (A group working with this objective in mind might help promote increased mutual trust between the manufacturer, the military, and other industrial users.)
9. The listing of potential "applications" should be a part of every specification, unless it covers a confidential end use. (Many product specifications are used to cover applications for which they were not intended. Unless the end use is known it is difficult to write a good product specification.)

"In closing, we would say that we, as a supplier, are interested in further study of the problem, and believe that the cooperative spirit shown at the EI Applications Conference will help us all in arriving at a more satisfactory solution."

G. O. Hunsinger

Chief Elec. Cable Design Engr., Electrical Wire Div., John A. Roebling's Sons Div., The Colorado Fuel and Iron Corp., Trenton, N.J.

"I cannot agree with Admiral Rickover on his idea (expressed at the 2nd National Conference on the Application of Electrical Insulation) that

specifications for electrical cable would result in an improvement if they were written by users rather than by manufacturers. His idea, however, has some merit depending upon the type of user involved.

"During the war, Admiral Rickover, as head of the electrical section of the Bureau of Ships, did prepare realistic specifications involving completely new cable designs for use on shipboard. I worked closely with the Bureau at that time along with the engineers of all companies manufacturing shipboard cable. The first committee to be formed was to develop watertight shipboard cable and the second committee was to develop a lightweight, smaller-diameter cable. Both of these committees were headed by Admiral Rickover and the civilian head of the cable section. In this case, the civilian head of the cable section had previously worked for many years with one of the major cable companies. The problems of the Navy and the manufacturer's problems were both known to him. The Bureau of Ships was, therefore, in a much better position to prepare specifications for cable used by it than is the average user.

"The average user knows little or nothing about the manufacturing processes and problems in making cable and is not in a position to write specifications for the cable. Any specifications written by a user that did not understand the manufacturer's problems would stand a good chance of being impractical in production.

"To resolve such a problem it would probably be best for the manufacturers to write specifications for cable as is the present practice, but perhaps the user should have an opportunity to review and approve the specifications before they become industry standards."

G. A. Cypher

Technical Director, Natvar Corp., Woodbridge, N.J.

"I believe committees concerned with setting up electrical insulation standards for the industry as a whole should be composed of both insulation users and manufacturers. To determine the level of properties which will meet the needs of most users and

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vhich can be produced at reasonable ;ost obviously requires discussion be-ween user and producer.

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Robert Herr

Technical Director, Electrical Prod-ucts Laboratory, Minnesota Mining and Manufacturing Co., St. Paul, Minn.

"I would like to divide my answer in two parts. First, with respect to types of tests and standardizing of test methods. This sort of activity is vital and is exemplified by a very good record by ASTM. Such work should be done by committees representing both users and manufacturers either equally or with a predominance of manufacturers. Within my limited experience this is the situation today, and except for the backlog of unre-solved problems and many areas of incomplete coverage, the procedures seem satisfactory. Furthermore, this work is important, since without an accepted method of using words, run-ning tests, and expressing results, manufacturers and users alike are handicapped in writing and in read-ing advertisements, product bro-chures, and material specifications.

"Secondly, there is the area of ma-terial performance specifications. In general I would agree that industry-wide material specifications written by manufacturers tend to include mostly those 'least common denomi-nators' which just about everyone can meet and accordingly fail to recognize and encourage product excellence. They may do actual harm by encour-aging reliance on inconclusive tests. Where such industrywide standards are necessary, greater dependence upon users' representation would probably be healthy. I don't think a committee composed solely of users would be bad in principle, but I think it would be very slow and ineffective, especially on new and improved prod-ucts, since it is usually the manufac-turers who have the earliest product experience and a concrete test basis from which to make proposals. A com-mittee of users alone is too likely to come up with mere goals or desirable objectives.

"Finally, I think that in many in-stances industry-wide specifications are neither desirable nor necessary, with the best incentive to manufac-turers and protection to users being obtained by restrictive specifications covering the desired superior product, which are arrived at by competitive negotiation between the customer and the vendors who have the superior product to offer."

New Publications

Books

Ten Founding Fathers of the Electrical Science, by Dr. Bern Dibner. Contains biographical sketches of Dr. William Gilbert, Otto von Guericke, Benjamin Franklin, Allesandro Volta, Andre Marie Ampere, Georg Simon Ohm, Karl Friedrich Gauss, Michael Faraday, Joseph Henry, and James Clark Maxwell. 48 pages, $1. Burndy Library, Norwalk, Conn.

European Technical Digests. New monthly published in English, Italian, Spanish, and Turkish. Contains information on new processes, methods, apparatus, or materials which could be readily employed in industry without large capital investment. Material is taken from over 1,000 technical journals appearing in 13 different countries and in 11 different languages. The purpose of the digests is to spread from one country to another technical information and knowledge likely to increase productivity and to crossfeed ideas from one industry to another irrespective of language barriers. Photocopies of the original articles and additional information are supplied on readers' request whenever possible. Yearly subscription is $12; $6 for six months. European Technical Digests, European Productivity Agency, Organization for European Economic Co-operation, 3, Rue Andre-Pascal, Paris 16. France.

Electronic Information Service Newsletter. Contains information about electronic industry advertising, sales, administration, supervision, directory listings, books, pamphlets, opportunities, methods, publicity, marketing, ideas, etc. Written primarily to convey management information. this newsletter does not contain advertising, feature articles, or new product news. Published monthly, $12.50 per year. Electronic Information Service. 8526-11th Ave. S., Minneapolis 20, Minn.

16th ANTEC Preprint Book, Volume VI, 1960. Contains the 83 technical papers presented at the 16th Annual Technical Conference of the Society of Plastics Engineers Inc. $7.50 to members; $12.50 to nonmembers. Single copies of individual papers are 25¢ each to members; 40¢ each to nonmembers. Order from SPE, 65 Prospect St., Stamford, Conn.

Encapsulation, Printed Circuits, and Fluidized Bed Processes. Contains 15 of the 23 papers presented at the Symposium sponsored by the Northern Indiana section and the Professional Activities Group on Plastics in Electrical Insulation of the Society of Plastics Engineers Inc. $3 to members; $4.50 to nonmembers. Order from SPE, 65 Prospect St., Stamford, Conn.

Electrical Insulation Application Conference Papers. Contains 78 papers presented at the Second Annual National Conference on the Application of Electrical Insulation (Dec. 1959). 204 pages, $6. Order from Mr. Fred Huber, National Electrical Manufacturers Assn., 155 East 44th St., New York 17.

ASTM Standards on Electrical Insulating Materials. This edition contains 108 standards of which 46 are new, revised, or have had their status changed since the previous edition in 1957. Hard cover, 792 pages, 6″ x 9″, $8.75. American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

OTS Reports

The following reports are now available from the Office of Technical Services, Business and Defense Services Administration, U. S. Dept. of Commerce, Washington 25, D.C.

PB 151919, Metal-Ceramic Receiving Tubes for Automatic Production, by W. H. Sain. 67 pages, $1.75.

PB 151830, Electron Tube Bulb Temperature Ratings, by M. W. Edwards. 76 pages $2.

PB 151958, Development Z-5219 100 Watt CW S-Brand TWT, by R. H. Winkler. 44 pages, $1.25.

59-21176, Index of Abbreviated and Full Titles of Scientific and Technical Periodical Literature. Lists all Soviet and foreign publications processed in abstract journals of the Institute for Scientific Information USSR Academy of Sciences. 23[illegible] pages, $4.

PB 161028, Use of Electrical Resistivity in the Study of the Polymerization of Thermosetting Resins. 1[illegible] pages, 50¢.

Other Government Publications

The following publications may be ordered from the Supt. of Documents Govt. Printing Office, Washington 25, D.C.

International Movement of Electric Motors, 1952-58. Includes tables on world consumption, production, trade and exports of electric motors. [illegible] pages, 20¢. Order Catalog No. C41.2: M85/2.

Handbook Preferred Circuits. NAVAER 16-1-519, Supplement No. 2. Contains five circuits (two transistor and three vacuum tube) and a brief note on preferred regulated voltages for transistorized equipment. 54 pages, 30¢.

NEMA Standards

The following new and revised publications are available at the prices indicated from the National Electrical Manufacturers Assn., 155 East 44th St., New York 17.

EI 1-1959, American Standard Requirements for Electrical Indicating Instruments (Panel, Switchboard, and Portable Instruments). $2.50.

MW 2-1959, Polyurethane-Coated Magnet Wire. 30¢.

MW 15-1959, Vinyl-Acetal-Coated Magnet Wire. 30¢.

MW 17-1959, Vinyl-Acetal-Nylon-Coated Magnet Wire. 30¢.

MW 19-1959, Vinyl-Acetal Self-Bonding Magnet Wire. 30¢.

SG 5-1959, Power Switchgear Assemblies, $4.

WD 2-1959, Wiring Devices. 20¢.

'acuum-Formed 'hermoplastic Sheet Iolds for Epoxy 'ncapsulation

A new method for insulating elec- ical components with epoxy resins ilizes vacuum-formed thermoplastic eet as the mold form. The new sys- m employs a skin wrap of "Camp- " thermoplastic sheet which is cuum-formed around the compo- nt. An opening is made at the top r lead wires to be brought out and e resin to be poured in. Cardboard tape is used to position the leads. 'hen the resin has been poured into e mold the part is ready for curing. ny number of articles of varying zes and shapes reportedly can be in-wrapped simultaneously, lim- ed only by the size of the vacuum- rming machine. Labor and material vings over the steel mold method e reported and where steel molds e now used, production can be in- eased by making a number of plas- c molds from the master mold. The ew method is being introduced by e Electrical Products Div., Minne- ta Mining and Manufacturing Co., d the Campco Div., Chicago Molded roducts Corp.

lectrical component that has been in-wrapped by vacuum forming of Campco" thermoplastic sheet. The mponent is now ready for resin lling.

Association News

Brumfield Elected Head Of Relay Manufacturers

Richard M. Brumfield was elected president of the National Association of Relay Manufacturers during the recent annual meeting at Miami Beach, Florida. Brumfield is president of Potter & Brumfield Div., American Machine & Foundry Co., and group executive of AMF's Electrical Products group. Other new officers are V. A. Hedlund, RBM Division of Essex Wire Corp., vice president; R. P. McAlister, Leach Relay Co., secretary; H. B. Steinback, Magnecraft Electric Co., treasurer.

Speakers on Printed Circuits Available

Speakers qualified to discuss the applications and utilization of printed circuits are available from a new speakers bureau developed by the institute of Printed Circuits. Members of the IPC have volunteered to participate in this speakers bureau to discuss such topics as designing, repairing, or applications for printed circuits. Speakers are available in most major cities. Organizations that are interested in obtaining qualified speakers to discuss the applications and uses for printed circuits can contact the IPC office, 27 E. Monroe. Chicago 3.

NISA Proposes Regional Seminars on New Insulation Materials and Equipment

A series of five or six regional meetings at which personnel of electrical apparatus service shops would test and learn to use new insulation materials has been proposed by the Engineer's Advisory Committee of the National Industrial Service Association. The "Regional Practical-Technical Seminars" would be two or three days long and would be held in various parts of the country, using materials and equipment furnished by manufacturerers and suppliers. Each seminar would be directed and supervised, however, by NISA's engineering department. A seminar would not be held until a minimum of 75 participants was guaranteed. A trial seminar will be conducted on March 25-27 by members of King Coal Chapter (Southern Illinois and parts of Missouri, Indiana and Kentucky).

IRE Conference and Electronics Show, Houston, April 20-22

The joint conference and electronics show of the Southwestern Institute of Radio Engineers and the National Professional Group on Medical Electronics will be held at the Shamrock-Hilton hotel, Houston, April 20-22. The technical program consists of 60 papers. The principal speakers will be Dr. R. L. McFarlan, National President of the IRE; Dr. Hubertus Strughold, Chief of the Air Force School of Space Medicine; and Dr. LeVan Griffis, Dean of Engineering at Rice University, Houston.

NISA to Become EASA On April 1, 1961

On April 1, 1961, the name of the National Industrial Service Association, Inc., will be officially changed to Electrical Apparatus Service Association, Inc. A new name for the association had been under consideration for many years. The organization was founded as the National Industrial Electrical Service Association in 1933, but the word "Electrical" was dropped a year later to attract memberships from the mechanical service industries. Although these companies have not been eligible for membership for many years, the word "Electrical" has never been restored. Meanwhile there has been an increasing demand from the organization's membership for a more descriptive name.

IRE International Convention In New York, March 21-24

The 1960 International Convention sponsored by the Institute of Radio Engineers is expected to attract an attendance of 60,000. It will be held March 21-24 at the Waldorf-Astori Hotel and the Coliseum in New Yo City. Said to be the largest technic event in the world, it will include program of 54 technical sessions an 850 exhibits covering all four floo of the Coliseum. The exhibits will b grouped with components on the fir and second floors, completed equi ment on the third, and fabricatio materials, and service on the fourt One of the highlights of the technic program will be a special symposiu on Electronics—Out of this World

EIA Seminar to Seek Proposals For More Defense per Dollar

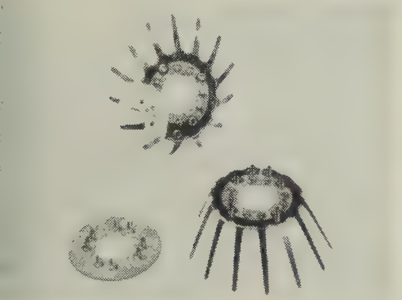
A seminar of top-level represent tives of the country's defense admi istration, military services, Congre and industry to develop specific pr posals for giving taxpayers more d fense per dollar has been announce by Electronic Industries Associati The seminar will be held March in the Statler-Hilton Hotel. Washin ton, D.C., and is expected to be a tended by several hundred perso from government and industry wi responsibility for marketing a planning in the defense area. It w precede EIA's Spring Conferen March 16-17 which will feature t association's annual Government-I dustry Dinner March 17. The se inar is being sponsored by EIA Military Products Division under t chairmanship of Sidney R. Curt senior vice president of Stromber Carlson.

NEMA Gains Six Members

Six companies have joined the N tional Electrical Manufacturers A sociation. They include the Ripl Co. Inc., Middletown, Conn.; Nort eastern Engineering Inc., Mancheste N.H.; Texas Instruments Inc., Att boro, Mass.; Gas Drying Inc., Cha ham, N.J.; International Instrumer Inc., New Haven, Conn.; and Hin Transformer Co. Inc., Flemingto N.J.

Iica "Anchor" in athode Ray Tube

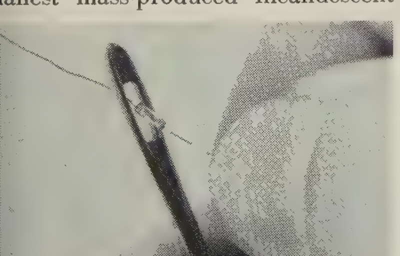
A thin disc of natural mica forms insulating "anchor" for compo- nts in a special type of cathode ray be. The entire assembly consists of mica disc, a spring nickel "spider"



ainer-aligner, and nickel eyelets. e split "spider" is mounted directly the 1.250″ diameter disc of Indian by mica, .015″ in thickness, with .056″ eyelets. Eight other nickel elets, fastened only to the mica disc, accurately spaced to receive other un" components and hold them in oper alignment. All dimensions re- rtedly are held to within .001″. tural mica was chosen as the in- lation because of its high dielectric ength, stability up to 1,000°F, ex- lent mechanical properties at all nperatures, and ease of fabrication close tolerances. The mica struc- re is stamped and assembled by rd Radio & Mica Corp., Brooklyn, Y.

iny Incandescent Lamp

A new incandescent lamp for use transistorized circuits in missiles, mputers, and electronic systems is all enough to pass through the eye a darning needle. Said to be the allest mass-produced incandescent



np in the world, the "Mite-T-Lite" s a nominal diameter of .040 inches. ominal body length is 0.125 inches. mp is made by Sylvania Lighting oducts, a division of Sylvania Elec- c Products Inc.

Pixilated Patents

By Mike Rivise

(Thirty-ninth in a series of odd and interesting inventions in the electri-onics field from the files of the U.S. Patent Office.)

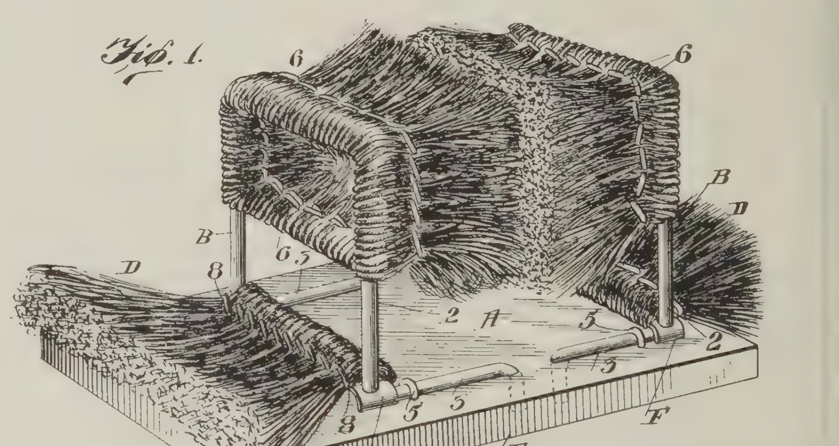
An invention patented by Marcellus M. Hitt in 1910 was tailor-made for those of us who normally get a charge out of standing on one foot and waving the other . . . it was supposed to generate static electricity by means of a foot swung back and forth between two brushes.

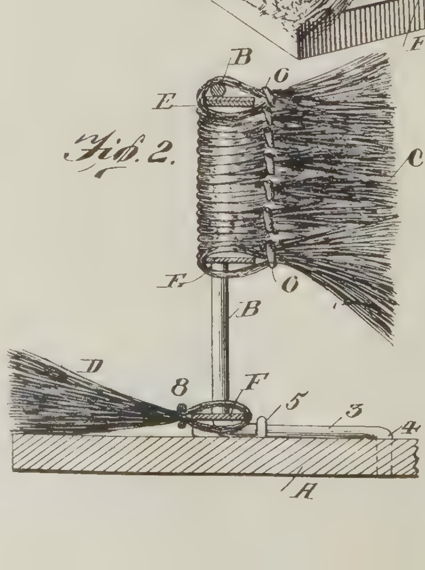
The device is described as "an improvement in apparatus for use in exercising, and developing and applying static electricity." The latter was expected to act as a "therapeutic agent" for the body of the user, but no further details are given with respect to the ills to be cured or the effects to be realized through application of the static electricity. Possibly the "therapeutic agent" reference was a polite way of indicating a means for recharging the bodily batteries, or at least getting started, after excessive activity the night before.

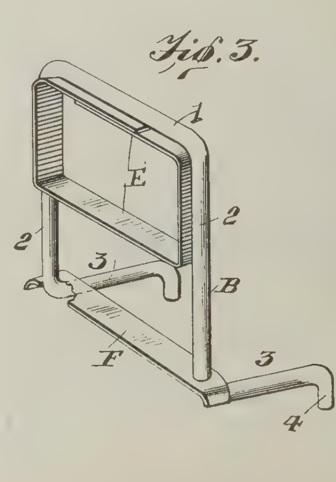
In the illustration A indicates a rectangular wooden base, B refers to bowed metal frames attached to the base and standing vertically, and C and D are brushes attached to these frames. The frames are formed of rods which for the sake of economy of manufacture are preferably made of round iron rods bent into the required form. They are duplicates in form and attachment and arranged opposite each other on the base. Each comprises a horizontal top portion 1, vertical side portions or legs 2, horizontal base portions 3, and hooks or toes 4 forming the terminals of the parts 3. The latter rest upon the base A and the toes 4 enter in the latter. Staples 5 are applied to the parts 3 at a point adjacent to the legs 2, and these, together with the toes 4, serve to hold the frames B rigidly in their required position. Within the upper portion of each frame B is arranged a sheet metal band E bent into a rectangular form, its ends overlapping directly beneath the top portion 1 of the frame B. The width of the band considerably exceeds the thickness of the rods to which it is secured. The tufts of the brushes C are secured to the frame support B and supplemental brush support E by looping them around the same and applying a wire clamp 6 on the inner side of the frames. The bands E furnish a broad supplemental support for the brushes whereby they are held in horizontal position as required. The brushes project toward each other, but are separated by a narrow space as indicated, their free ends flaring or diverging so as to make a wide brush surface. The collection of tufts forming the brushes D, which rest upon the base A and project outward from the frames B, is attached to the broad bands or flat bars F, which extend between and are attached to the legs 2 of each frame B, and the tufts comprising the brushes D are looped around the bands F and secured by wire clamps 8.

The patent states that, "In using the apparatus, a man should stand in his stocking feet with either foot on one side of the apparatus . . . with one foot on one of the brushes D which project laterally on the base H, and . . . (pass) the other foot and leg back and forth between the opposed brushes C. In this way, static electricity is generated, and the person or the user is charged with the same to a greater or lesser degree, while he derives benefit from the mere act of physical exercise."

In insisting on stocking feet it would seem that the inventor has overlooked an additional, and more practical, benefit which could be derived by allowing the user to keep his shoes on . . . and smearing a little polish on them before he begins his daily exercise.







You Can Pack a Big Protective Wallop Into MICA Insulation Parts

Recent technical developments have made mica even more versatile, more able to solve your insulation problems. It's available in more forms than ever before —from miniature insulation parts that pack an enormous protective wallop into tiny, critical electronic components . . . to huge manufactured mica pieces which must shrug off punishing abuse in power equipment. Because of the many forms in which Asheville-Schoonmaker mica is available, its properties can be varied to suit your specific needs and applications . . . extreme heat resistance, high strength, flexibility, and space savings are just a few of these characteristics. And all forms of mica feature exceptional electrical insulation qualities.

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. . . . . New York 13, N.Y., 271 Church St. . . . . .
. . Rocky River, Cleveland, Ohio, P. O. Box 2862 . .

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- provide high strength and low shrinkage
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- meet military specs. 27A and 16923

Write, wire, or phone today for Marblette's new electrical selector chart, with complete listings of properties and detailed information on uses of all Maraset E Series resins:

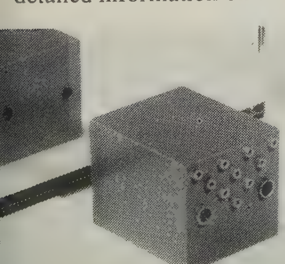

Photo courtesy Cosmos Industries

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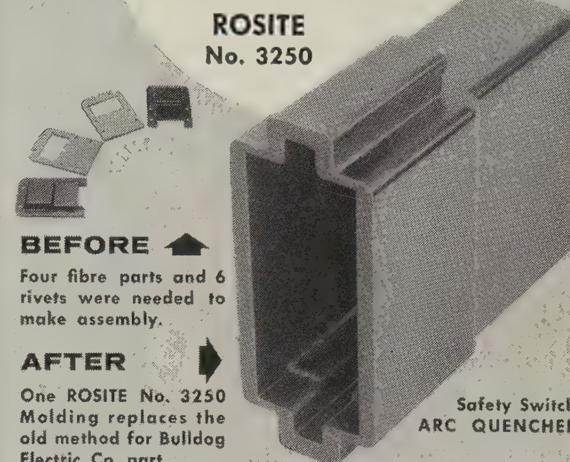
NOW! HOT-MOLDED ROSITE®

NON-TRACKING *ARC QUENCHING

Electrical Moldings

ROSITE No. 3250



BEFORE

Four fibre parts and 6 rivets were needed to make assembly.

AFTER

One ROSITE No. 3250 Molding replaces the old method for Bulldog Electric Co. part.

Safety Switch ARC QUENCHER

HERE'S dramatic proof of the benefits that are available to users of new hot-molded ROSITE. The snuffing head above carries a shorting bar for closing stab type switch blades. By using ROSITE, the manufacturer substituted a single molded part for a 10-piece assembly. The savings were obvious and the new ROSITE molding had better *non-tracking* and *arc quenching* qualities as well.

SIZE REDUCTIONS—ROSITE hot-mold compounds can offer size reductions because they possess non-tracking . . . arc-quenching qualities which make smaller ROSITE parts do a better job than larger assemblies or moldings. A real boon to designers!

ECONOMICAL—Save on size, weight and cost. Send us your drawings, let us study your problem. Then we can quote to show how ROSITE does a better job for less. Do it today for your products' sake!

***PATENTED**—ROSITE'S new hot-mold No. 3250 incorporates a patented arc-quenching characteristic. This is a new dimension in hot mold compounds, now making it possible for Rostone Corporation to offer the same properties that have made ROSITE cold moldings the standard for quality electrical parts.

SEND FOR NEW CATALOG

ROSTONE CORPORATION

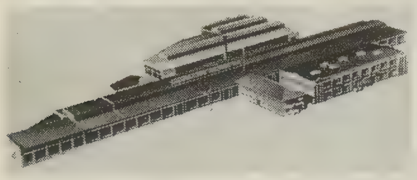
2409 S. Concord Road, Lafayette, Indiana

For Canadian requirements contact Electro Porcelain Ltd., Kitchener, Ontario

Print Ins. 36 on Reader Service Card

Industry News

Modern Plastic Machinery Corp. has tripled its facilities by moving to



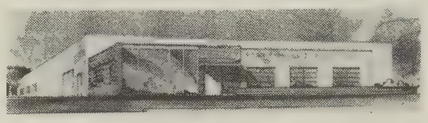
an 80,000-sq. ft. plant in Clifton, N.J.

McGraw-Edison Co., by means of a cash purchase, has acquired the evaporative cooler and central air conditioning business of *International Metal Products Co.* and *Continental Manufacturing Co.*, Phoenix, Ariz. The new operation will be known as the *International Metal Products Division.*

Electro-Logic Corp. has been founded in Venice, Cal., for the manufacture of electronic instruments. Vincent A. van Praag is president and George J. Giel is vice president for engineering.

Charles E. Babcock Co., Wayne, Pa., has been formed as a sales representative company in the electronics field.

North Hills Electric Co. Inc., Mine-



ola, N.Y., is moving to a new plant in Glen Cove, N.Y.

Alpha Wire Corp., New York City, has opened a new Pacific Division of factory facilities, warehouse, and offices in Los Angeles. Donald Rappaport, formerly assistant sales manager, will manage the new operation.

Aluminum Co. of America, Pittsburgh, has announced plans for a new multi-million dollar research and development center at Merwin, Pa., with construction starting date yet to be determined.

Minnesota Rubber Co. has completed its 14th plant expansion since 1946 bringing total manufacturing area to approximately 120,000 sq. ft.

The Polymer Corp., Reading, Pa., has formed a "Whirlclad Division" and a "Molding Resins Division" to handle the fluidized bed coating process and sales of molding compounds, respectively.

A 75,000-sq. ft. addition is planned for the Dallas, Texas, facilities of *Continental Electronics Manufacturing Co.*, subsidiary of *Ling-Altec Electronics Inc.*

West Virginia Pulp & Paper Co., New York, increased 1959 sales over 1958 by 12% to $233,000,000. Net earnings increased 23% to $11,800,-000.

Minnesota Mining & Mfg. Co., St. Paul, reports 1959 sales of about $445,000,000, 18% above 1958. The company also announced that operations of the High Point, N.C., branch have been moved to a newly completed building with 12,000 sq. ft. of

ice space and 33,000 sq. ft. of ware-use space.

Taylor Fibre Co., Norrisown, Pa., minated plastic and fibre producer, ports 1959 sales of $9,100,000, up % over 1958. 1960 sales over 0,000,000 are expected.

Northern Plastics Corp., LaCrosse, is., laminated plastics manufacturer, ports sales for the quarter ended ecember 31, 1959, of $1,243,967, up % over the comparable 1958 pe-od. Net earnings for the quarter re $79,962 compared with $64,286 r the 1958 quarter.

Hercules Powder Co., Wilmington, el., reports net sales of $283,650,000 r 1959, up 20% over 1958 and net come of $23,500,000 compared with 7,509,000 for 1958.

Dayton Rubber Co., Dayton, Ohio, nounced 1959 fiscal year sales of 01,838,313, up 19% over 1958. Net ofits for fiscal 1959 total $2,414,226 mpared to $1,324,434 for 1958.

Accurate Specialties Co. Inc., Wood-de, N.Y., ceramics and electronics anufacturer, reports semi-annual 59 sales of $539,500 compared to $255,700 for the same period of 1958. Net profits after taxes for the period amounted to $22,000.

Raychem Corp. (meaning radiation chemistry) is the new name for *Raytherm Corp.*, Redwood City, Cal., producer of irradiated electrical and electronic insulations and components. The company is presently expanding

its facilities to bring its total working area to 60,000 sq. ft. and increase its capacity by 400%.

Whirlpool Corp., St. Joseph, Mich., has formed a special products division under the direction of vice president Robert B. Willemin to explore and develop new product ideas.

Borden Chemical Co., New York, is constructing a polyvinyl chloride plant at Illiopolis, Ill., with a capacity of 40,000,000 lbs. The company also announced purchase of land in Fremont, Cal., to be used as the construction site for its recently announced 90,000,000 lb per year resins and formaldehyde plant. The resins plant is expected to be completed in April.

Dr. Charles E. Reed, general manager of *General Electric's Chemical and Metallurgical Div.*, is shown christening "Riverview," new home of

the Insulating Materials Dept. at Rotterdam, N.Y. Others in the photograph are Schenectady Mayor Malcolm E. Ellis, T. C. Ohart, general manager of the Insulating Materials Dept., supervisor John Kirvin of Rotterdam, and A. C. Stevens, manager of public and employee relations.

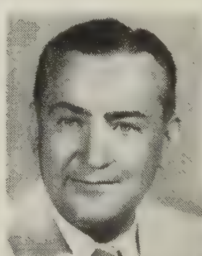
Houghton Laboratories, Olean, N.Y., manufacturer of epoxy electrical insulation products, has changed its name to *Hysol Corp.*

People in the News

Rogers Corp., Rogers, Conn., plastics, rubber, and fibrous material producer, has made the following appointments: *George B. Archer* has been named manager of the Killingly Div., and *Roy A. Rosen* has been appointed chief tool and die engineer for the division. *A. David Chesmer* has been promoted to division manager for the Rubber Div. in Willimantic. Conn. *Lee Hennessy* has joined the company as a market development engineer.

Joclin Manufacturing Co., Wallingford, Conn. reinforced plastics producer, has named *Richard M. Clark* as sales manager, *Kerin G. Boardman*, West Coast regional manager, and *Arthur J. Goodwin, Stephen C. Markham*, and *Bedford Byron* as representatives.

J. S. Urbanik has been named manager of the Kaiser Aluminum and Chemical Corp. wire and cable works at Bristol, R.I. He will continue to serve as division manager of plant operations. *F. S. Bartlett*, former Bristol works manager, has been appointed to the newly created executive position of division product projects manager.



J. S. Urbanik

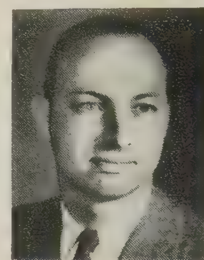
F. S. Bartlett

Erwin F. Wolf, previously with Reeves Instrument Corp., has joined Dynatran Electronics Corp., Mineola, N.Y., as chief electronics engineer.

Narda Microwave Corp., Mineola, N.Y., has named *Thomas M. Lyons* as quality control manager.

James L. Donahue has been promoted from assistant sales manager to general sales manager for Catalytic Combustion Corp., Detroit.

Charles N. Muldrow Jr., has been appointed head of the Polymerization Laboratory, Dielectric Materials Group, American Enka Corp., Enka, N. C. He had been with Shell Development Co.



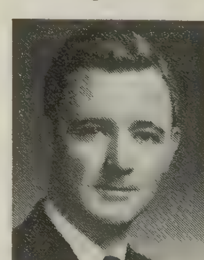
C. N. Muldrow

C. H. Sparklin

Whirlpool Corp., St. Joseph, Mich., has announced the retirement of *Charles H. Sparklin*, engineering executive and former official of the Birtman Electric Co., Chicago. He holds more than 50 patents and now plans to become a private engineering consultant.

William N. Lucke, former Lt. Col. U. S. Army Corps of Engineers, has joined Philco Corp.'s Government and Industrial Div. as systems manager.

James F. Riley, previously sales engineer in Los Angeles, has been named field sales manager for Corning Electronic Components, a department of Corning Glass Works in Bradford, Pa., which produces Fotoceram circuit boards, capacitors, resistors and metallized glass components. *George B. Jensen* replaces Riley in Los Angeles.



J. F. Riley

P. S. Hessinger

Philip S. Hessinger has been named manager of research, National Beryllia Corp., North Bergen, N.J., ceramic producer. He had previously been with Mycalex Corp. of America.

Robert R. Goldsborough has been named manager of the AN/ASD-1 program for development and design of airborne electronic equipment at the Mountain View, Cal., operation

Sylvania Electronic Systems, Div. Sylvania Electric Products Inc. ther appointments for the program clude *Robert L. Amelang* as admin- :rative staff supervisor, *Rudolph ızanjian* as quality assurance super- sor, and *Melbourne J. Myers* as tech- cal manager.

Alfred S. Backus, previously acting neral manager and works manager, is been elected vice president, oper- ions, Mycalex Corp. of America and s affiliated companies, Mycalex Elec- onics Corp., Mycalex Tube Socket orp., and Synthetic Mica Co., Clif- n, N.J.


A. S. Backus *R. W. Fromme*

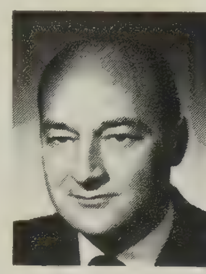
Formica Corp., Cincinnati lami- ated plastics producer, has named *obert W. Fromme* production man- ger, industrial products. He had een assistant production manager.

John J. McDonald and *Linden G. riddle* have been elected vice presi- ents of Consolidated Systems Corp., subsidiary of Consolidated Electro- ynamics Corp. in Monrovia, Cal. IcDonald will continue as director of ngineering and Criddle as director f operations.

The motor and generator depart- ıent of Allis-Chalmers Manufactur- ıg Co., Milwaukee, has named *James '. Rhodes* assistant engineer, insula- ion section, and *Robert L. Linn* and *'ichard M. Willets* assistant engi- eers, production coordination sec- ion. Engineers *Ole N. Ibsen* and *'harles J. Schwarz* have been assigned) the control department. *Dominik 'ortunato* and *Maldon D. Laitinen* ave been appointed assistant engi- eers in the nuclear power depart- ıent's core engineering group.

Consolidated Electrodynamics 'orp., a subsidiary of Bell & Howell 'o., Pasadena, Cal., has promoted *'aniel E. Murphy* from administra- ion manager to director of the Data- ıb Div. The firm also named *Edward P. Fleischer*, formerly assistant to the president as an assistant director for the Electro Mechanical Instrument Div.

Simon J. Warschauer has been appointed national sales manager for Viking Wire Co. Inc., Danbury, Conn. Warschauer, previously general manager for Electric Conductors Inc., recently established a magnet wire plant in Puerto Rico.




S. J. Warschauer *Walter T. Buhl*

Walter T. Buhl, formerly vice president and general manager of the Leland Electric Co. Div., American Machine & Foundry Co., has been named deputy group executive of AMF's Electrical Products Group with headquarters at Vandalia, Ohio.

Herbert R. Lilley, previously Detroit office manager, Packard Electric Div., General Motors Corp., has been named sales manager, Cable Products, at the division's home office in Warren, Ohio. *Robert H. Sims* succeeds Lilley as manager of the Detroit office.

L. Dean Tyler, formerly manager of foam and specialty chemical sales, has been appointed sales manager for polycarbonate resins by Mobay Chemical Co., Pittsburgh.

International Resistance Co. has named *Duane C. Manning*, formerly sales manager of the West Coast Div. of Fairchild Controls Corp., as manager of engineering sales in the Pacific area.

J. R. Johnson, previously executive vice president, has been elected president of Royal Industries Inc., Los Angeles.

Thwing-Albert Instrument Co., Philadelphia test instrument producer, has elected *John Fachet* as vice president, manufacturing, *Ralph E. Green* as vice president, technical sales and quality control, and *Charles A. Paul Jr.* as secretary.

New Products

For further information on these products, print the item number on the Reader Service Inquiry Card on the back cover. Fill out and mail the card—no postage is required. Insulation *will immediately forward your inquiry to the manufacturers concerned so that they can send you more information promptly.*

New Silicone Dielectric Fluid for Both High and Low Temperature Uses

A new electrical grade silicone fluid is said to combine excellent electrical properties with an extremely low-temperature pour point. Identified as SF-85 (50), its pour point reportedly is below —120°F (—84.4°C) which makes it especially suitable as a dielectric in extremely low-temperature applications. The viscosity is 50 centistokes at 25°C (77°F) and viscosity change at temperature extremes is stated to be less than that of conventional silicone fluids, allowing application in airborne equipment subjected to both high and low temperatures. Potential uses include application as a dielectric in transformers, capacitors, fluid-filled electronic components, and as a heat transfer medium and liquid dielectric for fluid-cooled electronic assemblies. Silicone Products Dept., General Electric Co., Waterford, N.Y.

Print No. Ins. 101 on Reader Service Card

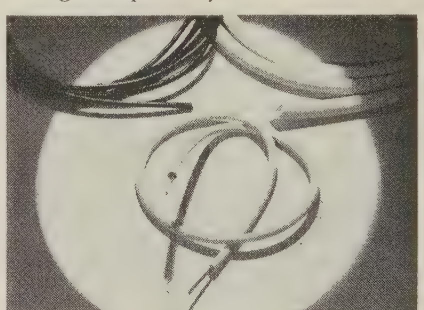
New Epoxy Resins for High Temperature Insulation

New "Oxiron" series of epoxy resins for electrical and electronic insulation, encapsulation, molding, lamination, adhesion, and coating, is claimed to differ from conventional epoxies in structure, reactivity, and end-properties. The resins reportedly react readily with anhydrides, combine excellent electrical properties with superior strength and stability at high temperatures, can be cured at relatively low temperatures, and exhibit low shrinkage and low exotherm on cure. Other features are said to include ability to wet glass fibers readily and show good adhesion on cure, ability to form laminates which have excellent strength-to-weight ratios under low pressure in relatively short cure cycles, excellent resistance to chemical attack, and cost and handling advantages. Bulletin available. Epoxy Dept., Chemicals & Plastics Div., Food Machinery and Chemical Corp., 161 East 42nd St., New York 17.

Print No. Ins. 102 on Reader Service Card

New Silicone Rubber Extruded Tubing Remains Flexible at High Temperatures

"Flexite" SR silicone rubber extruded tubing is said to exhibit outstanding flexibility, retaining elasticity after long exposure to temperatures from —85°C to 225°C. Its tensile strength, elongation, and tear strength reportedly are excellent, as



is its resistance to corona, oils, and weathering. Flexite SR withstands short term temperatures to 315°C, and is rated for continuous use at 200°C. Samples and data on request. L. Frank Markel & Sons, Norristown, Pa.

Print No. Ins. 103 on Reader Service Card

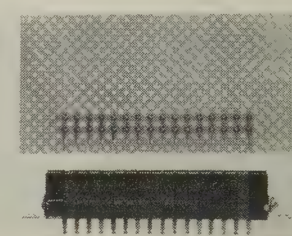
New "Teflon" Tape with Low Shrinkage for Wire Wrapping

A new Teflon tape for use on wire conductors requiring insulating materials which are capable of withstanding prolonged exposure to high temperatures without cracking or splitting is specified to show no more than 2% change in any dimension when heated free at 730°F (388°C) for 15 min. The skived tape is available in thicknesses from 1 mil up and in widths from 1/4" to 12". In the 1 mil thickness tensile strength is 3000 psi, elongation is 250%, and dielectric strength is 3800 vpm. Dixon Corp., Bristol, R.I.

Print No. Ins. 104 on Reader Service Card

"Plugbords" for Making Prototype Printed Circuits

Printed circuit designs reportedl can be quickly and inexpensively lai out and tested in prototype using Plu bords. Plugbords are supplied i 1/16" thick epoxy paper material wit .062" holes on alternate intersectio of 0.1" grid. A 16-pin Elco "Varico Series 5001 connector is attached



the leading edge and this mates wi a Varicon Series 7001 16-contact r ceptacle. Plugbords, using Vect push-in or stand-off terminals, ma be hand wired to provide prototyp for final printed circuit cards. Plu in test circuits for laboratory use ma also be built on Plugbords. Vario sizes are available. Vector Electron Co., 1100 Flower St., Glendale 1, C

Print No. Ins. 105 on Reader Service Card

New Insulating Material Permits Higher Transformer Loadability

A new insulating material, HT 5 reportedly permits higher therm overloads in oil-filled transforme with no sacrifice of insulation life. is claimed to give the same life e pectancy at 135°C operating tempe atures as standard transformer insul tion papers and boards give at 105° Inert in both standard and inhibit transformer oils, the material is al said to be comparable with standa insulating media in oil absorptic formability, and other physical pro erties. HT 50 is available for fie evaluation in sheets of thickness from .031" to .250". Spaulding Fib Co. Inc., 310 Wheeler St., Tonawa da, N.Y.

Print No. Ins. 106 on Reader Service Card

New Polyester Wire Enamel With 175°C Thermal Resistance

A new "Alkanex" class F polyest wire enamel is said to be capable

withstanding temperatures of as much as 175°C and is believed to have the highest thermal resistance of any polyester wire enamel yet developed. Key features claimed are excellent runability which enables it to be applied to all sizes and shapes of magnet wire, and improved dielectric strength and Freon resistance which make it suitable for hermetic motor applications. Laboratory tests also have indicated the new insulation undergoes lower stack losses than modified polyester wire enamels. A safety factor of about 40% against thermal overload and cut-through values ranging from 290 to 315°C are reported. General Electric Co., Schenectady 5, N.Y.

Print No. Ins. 107 on Reader Service Card

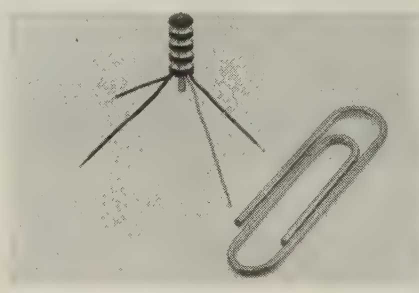
Flame-Retardant, Copper-Clad Paper-Phenolic Laminate

A new copper-clad, hot-punch, paper-base phenolic laminate, called either "Fireban" 321-R or "Fireban" 321-E depending on whether copper foil is rolled or electrolytically deposited, reportedly meets tentative Underwriters Laboratory requirements for flame retardance. The material also is said to possess excellent punching and electrical characteristics, including high insulation resistance and surface resistivity. It is offered in sheets of approximately 36″ x 48″, in thicknesses from .020″ to ¼″. The base stock is translucent and can be cold-punched to 1/16″ in thickness. Maroon in color, it is furnished with a semigloss finish. Taylor Fibre Co., Norristown, Pa.

Print No. Ins. 108 on Reader Service Card

Epoxy Compounds for High Speed Molding of Electrical/Electronic Parts

New EMC epoxy molding compounds are said to have soft-flow molding characteristics which make possible high-speed molding of many electronic and electrical parts from materials previously found unworkable in manufacturing processes. Other advantages claimed include an



outstanding balance of physical, electrical, and chemical properties in an easily handled single component system; low pressure transfer and compression molding; and nonoutgassing, self-extinguishing, and self-releasing properties. Uses range from molding of miniature electronic parts smaller than a paper clip to the manufacture of giant electrical transformers. American-Marietta Co., Adhesive, Resin & Chemical Div., Seattle 44, Wash.

Print No. Ins. 109 on Reader Service Card

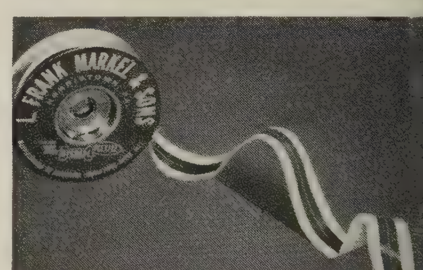
Improved Curing Agent For RTV Silicone Rubber

The preparation of RTV (room temperature vulcanizing) silicone rubber is now claimed to be improved and simplified with three new paste-type curing agents. RTV liquid silicone rubber, used in sealing, potting, and encapsulating applications, cures at room temperature after the addition of a curing agent. The new curing agents, RTV-992, -993, and -994, simplify and improve the processing of RTV compounds in several ways. By diluting the liquid curing agent into a paste, a greater quantity is required to effect a cure. As a result, it is easier to accurately weigh and measure the catalyst. Moreover, the addition of color to the paste curing agents, in contrast with the color of the RTV compounds, helps assure thorough mixing and complete dispersion. The three available types of paste curing agents offer the user a broad range of curing conditions to meet specific application requirements. Depending upon the percentage of curing agent used and particular RTV compound required, pot life and tack-free-time can be controlled from 15 and 30 minutes respectively to several days. Silicone Products Dept., General Electric Co., Waterford, N.Y.

Print No. Ins. 110 on Reader Service Card

New Silicone Rubber Triangular Guide Line Tape

"Flexite" silicone rubber triangular guide line tape is claimed to be a permanently resilient, self-adhering, self-fusing tape for void-free insulation with long life and resistance to corona,

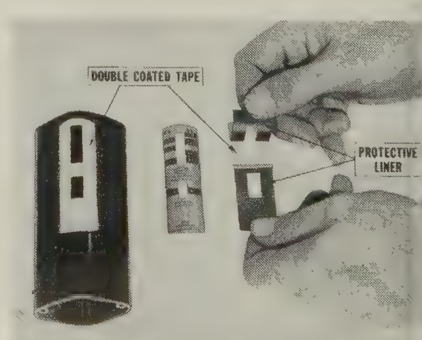


oils, weathering, and abrasion. The guide line reportedly cuts taping time and provides a lap with uniform thickness. Samples and data on request. L. Frank Markel & Sons, Norristown, Pa.

Print No. Ins. 111 on Reader Service Card

Pre-Cut Double Coated Tape For Low Cost Bonding

Positive, permanent bonding of plastics, wood, metal, and fabric sur



A new product of 3M Research!

"SCOTCH" Brand Electrical Tape No. X-1099 has all the electric strength of fully-cured epoxy resin, with all the mechanical strength of glass cloth, combined in convenient pressure-sensitive tape form for Class F (150° C.) applications. Adhesive is non-corrosive and thermosetting. Backing is fully compatible with epoxy resin insulating systems — cleavage planes are eliminated. Write for complete information: 3M Co., 900 Bush Ave., St. Paul 6, Minn., Dept. EAE-30.

"SCOTCH" IS A REGISTERED TRADEMARK OF 3M CO., ST. PAUL 6, MINN. EXPORT: 99 PARK AVE., NEW YORK 16. CANADA: LONDON, ONTARIO

lectrical Products Division | MINNESOTA MINING AND MANUFACTURING COMPANY ...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

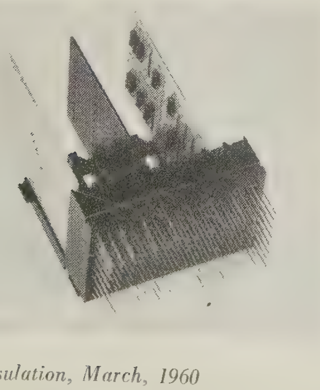
Print Ins. 46 on Reader Service Card

faces in manufacturing and assembly operations is reportedly done faster and more economically with pre-cut double coated tape products. The new products are manufactured from self-sticking tapes coated with a pressure-sensitive adhesive on both sides. The tape is precision-cut to meet product requirements—usually to the exact size and shape of one or both of the surfaces to be joined. The pre-cut pieces are furnished to the user mounted on handy dispenser-cards or liners. The double-coated tape products can be substituted in practically any application where liquid or paste adhesives are used—will replace many types of metal fastening devices in assembly operations. A typical use is to secure small electrical parts in radio and television sets and appliances. A variety of double coated tapes, many with special properties, can be supplied to meet application requirements. Examples are micro-thin tapes . . . high tack tapes . . . glass cloth tape . . . polyester film where high dielectric strength is a necessity. W. H. Brady Co., Dept. DC, 727 West Glendale Ave., Milwaukee 9, Wis.

Print No. Ins. 112 on Reader Service Card

Phenolic Molding Compound

RX 525, an improved type of impact phenolic molding compound, features ability to be molded under low pressures in combination with a flow rate deliberately lengthened to assure uniform distribution around closely spaced pin locations. The material is used for the printed circuit receptacles that make up the standard modular system in International Business Machines' recently announced equipment. Physical characteristics desired in conjunction with the molding properties were sufficient impact and flexural strengths to withstand the shock



of automatically driving 128 phosphor bronze (tin coated) contacts into the molded material. Rogers Corp., Rogers, Conn.

Print No. Ins. 113 on Reader Service Card

Epoxy Resin System for Potting, Casting, and Impregnating

Two new, nontoxic, epoxy resin systems are designed for potting, casting, and impregnating of electrical/electronic components and parts. By varying the ratio of resin to curing agent in the first system, RCM resin 2 and curing agent S, the degree of hardness or flexibility required—from the flexibility of soft rubber to the hardness of the typical epoxide resin—reportedly can be achieved. Expected applications include potting and casting of electronic components and casting of cables and cable junctions. The second system, RCM resin 130 and curing agent D, is a filled formulation developed for use in electronic components where excellent electrical properties and superior thermal and mechanical shock characteristics are required. The flexible system is designed for potting, impregnating, and casting of class F units. Pot life is reported to be six days at room temperature. Resin Consultants & Manufacturing Co. Inc., 132 Nassau St., New York 38.

Print No. Ins. 114 on Reader Service Card

Preprinted Sleeves for Identifying Wires, Cables, and Harnesses

Permanent identification of wires, cables, and harnesses reportedly is provided by "Shur-Code" sleeves which slip on over the wires. Preprinted to specifications on one, two, or more places, Shur-Codes are available in a complete range of sizes and standard and special materials which meet military specifications. Among special materials available is a silicone-rubber coated insulation sleeving for applications involving high temperatures (—90°F to +392°F); resistance to fluids, solvents, abrasion, and fungus; and for high insulation needs and long, effective life. Another special material is WHT-700 heat-reactive "shrinking" tubing for applications requiring tight fit and fluid and solvent resistance. When exposed to a few seconds of 275°F (135°C) heat, the sleeve shrinks to a tight fit of predetermined size. This material reportedly withstands abrasion and scuffing and grasps tightly to wires, lugs, terminals, fittings, and irregular surfaces. Temperature range claimed is —67°F to +300°F (—55°C to 149°C). Westline Products, 600 East 2nd St., Los Angeles 54.

Print No. Ins. 115 on Reader Service Card

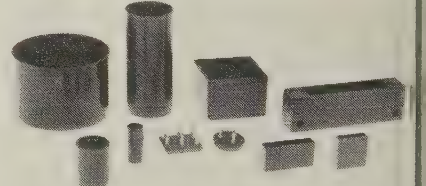
Silicone Dielectric Greases for Extreme Temperature Conditions

Two new silicone dielectric greases designed for use in applications subjected to temperature extremes are soft, workable greases that are chemically inert and can be used over a broad PH range. The new greases, XS-4006 and SS-4005, reportedly maintain their consistency from —65°F to 400°F (—54°C to 204°C) and offer excellent dielectric properties as well as good water repellency and oxidation resistance. Formulated to minimize oxidation of copper conductors, XS-4006 is said to be an ideal insulating material for use around copper wire and splices. The other compound, SS-4005, is designed for general purpose electrical applications. Particularly suited for aircraft automotive, and electronic applications. SS-4005 can be used as a corrosion inhibitor, water repellent seal insulator, lubricant, and damping and heat transfer media. Silicone Products Dept., General Electric Co., Waterford, N.Y.

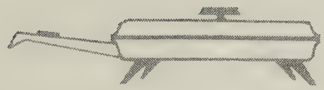
Print No. Ins. 116 on Reader Service Card

New Epoxy Molded Electronic Component Cases for Potting

High temperature epoxy electronic component cases are now available in a wide range of round, square, and



rectangular shapes and sizes. These cases, serving as molds during potting of the electronic components, reportedly eliminate the need for a large inventory of expensive molds and simplify assembly line operations. In addition, they are stated to insure the required minimum amount of epoxy



SPAULDING *800* ROD

Puts More "Skill" in Electric Skillets

Thanks to this tiny insulation pin, housewives now get exact temperature control in their cooking appliances because manufacturers are able to design a better product.

It's made of Spaulding 800 Rod material and used in the temperature control dial of electric fry pans.

Spaulding 800's extremely high dimensional stability under heavy moisture conditions helps the dial maintain factory-set temperature calibration and control indefinitely.

800 is another example of a new material developed through the research facilities at Spaulding to meet the changing needs of industry.

Progress Reports on other new Spaulding materials are available on request.

Spaulding 800 Offers These Unique Characteristics

SPAULDING FIBRE COMPANY, INC.

343 Wheeler Street, Tonawanda, New York

ELECTRICAL GRADES	XXX-800 (Paper Base)	LE-800 (Linen Base)
Diameter Tested	¼"	¼"
Water Absorption %	.46	.42
Specific Gravity	1.35	1.37
Flexural Strength PSI	28,000	26,000
Tensile Strength PSI	16,700	21,000
Compressive Strength Axially	24,000	30,000
Charpy Impact Strength Ft. Lbs.	.25	.38

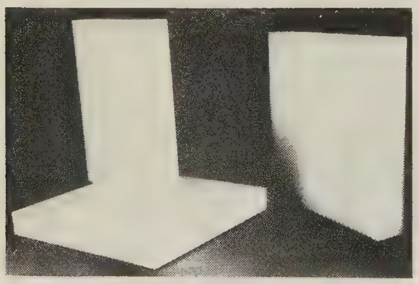
Print Ins. 47 on Reader Service Card

material around the encapsulated components. Component cases molded of epoxy become integral with the encapsulated components, providing the inherent high dielectric characteristics, low moisture absorption, high dimensional stability, good mechanical strength, and excellent chemical resistance of epoxies. Plastronic Engineering Co., 721 Boston Post Rd., Marlborough, Mass.

Print No. Ins. 117 on Reader Service Card

Polypropylene Blocks

Availability of a complete line of polypropylene block has just been announced by the American Agile Corp., Maple Heights (Cleveland) Ohio. The announcement is of particular significance because the material is ideal for elevated temperature and rigid construction service, also for nuclear shielding. It allows the user to make a prototype to his own design for in-plant or in-field testing, or for ultimate customer approval, prior to costly investment in production tooling. Chief characteristics claimed for the



material: it can be easily machined, ground, drilled, threaded and welded with standard woodworking or machine tools and equipment; it provides excellent impact resistance; and of great importance, it will withstand temperatures up to 240°F under average service load conditions. Blocks are available from stock in sizes ranging from 1″ x 12″ x 12″ and weighing 4.7 lbs. to 3″ x 12″ x 24″ and weighing 28.2 lbs. Prices range from $11.75 to $63.45 per block, depending on size. American Agile Corp., P.O. Box 168, Bedford, Ohio.

Print No. Ins. 118 on Reader Service Card

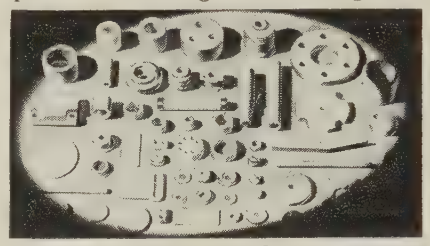
Plastic Pipe

New K&M plastic pipe and fittings are available in ABS (acrylonitrile butadiene styrene), PVC (polyvinyl chloride), and polyethylene. K&M plastic pipe is said to offer a permanently smooth bore, convenient 10 and 20-foot lengths, high strength, and light weight. The pipe cuts cleanly with a handsaw and sections are joined easily by means of a solvent weld. Keasbey & Mattison Co., Ambler, Pa.

Print No. Ins. 119 on Reader Service Card

Improved Forsterite Ceramic for High Frequencies, Metal or Glass Seals

An improved forsterite ceramic, AlSiMag 243, is reported to have low loss, high Te value, and favorable thermal expansion characteristics. It is designed for use where high frequencies or sealing to metals or glasses



is involved, particularly in vacuum tube applications. Test discs approximately ½″ x 3/32″ are available. American Lava Corp., Manufacturers Rd., Chattanooga 5, Tenn.

Print No. Ins. 120 on Reader Service Card

Flexible Aluminum Oxide Insulated Wire and Strip for Use to 1900°F

New flexible aluminum oxide insulated strip and wire is said to be good for temperatures as high as 1100°F (593°C) and, in certain forms, as high as 1900°F (1038°C). The anodized wire or strip in all gauges and sizes is made by a continuous anodizing process which reportedly provides a coating that is highly flexible and capable of withstanding

a great deal of deformation without fracturing or crazing the film. The 3800°F melting point of aluminum oxide should permit using metal strips in such units as transformers without cooling. The film thickness is stated to be carefully controlled from as low as 0.00008″ to 0.001″. Use of aluminum oxide insulated aluminum strips in large or small electronic units is claimed to give both savings in space and weight reductions of up to 50% compared to conventional materials. The flexible aluminum oxide insulation can also be applied to nickel plated copper strip or wire and to silver for applications close to the approximate 1900°F melting point of the bare conductor. Technical bulletin available. Permaluster Inc., 2012 West Burbank Blvd., Burbank, Cal.

Print No. Ins. 121 on Reader Service Card

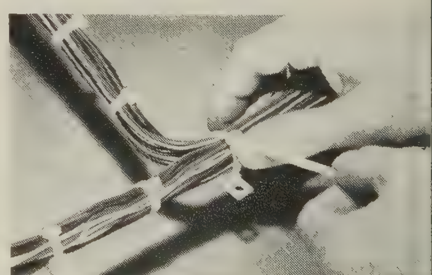
Waterproof Vinyl Cloth Wire Markers

Pressure-sensitive vinyl cloth wire markers are reportedly available on new quick-release dispensers which enable markers to be peeled off easily, smoothly—and applied without distortion. Waterproof vinyl markers in stock include all standard wire and electrical markers, numerals, and letters. They are claimed to be unaffected by grease, dirt, oil, and abrasion; to be always legible; and to conform to NEMA-ASA specifications. North Shore Nameplate Inc., 214-27 Northern Blvd., Bayside, N.Y.

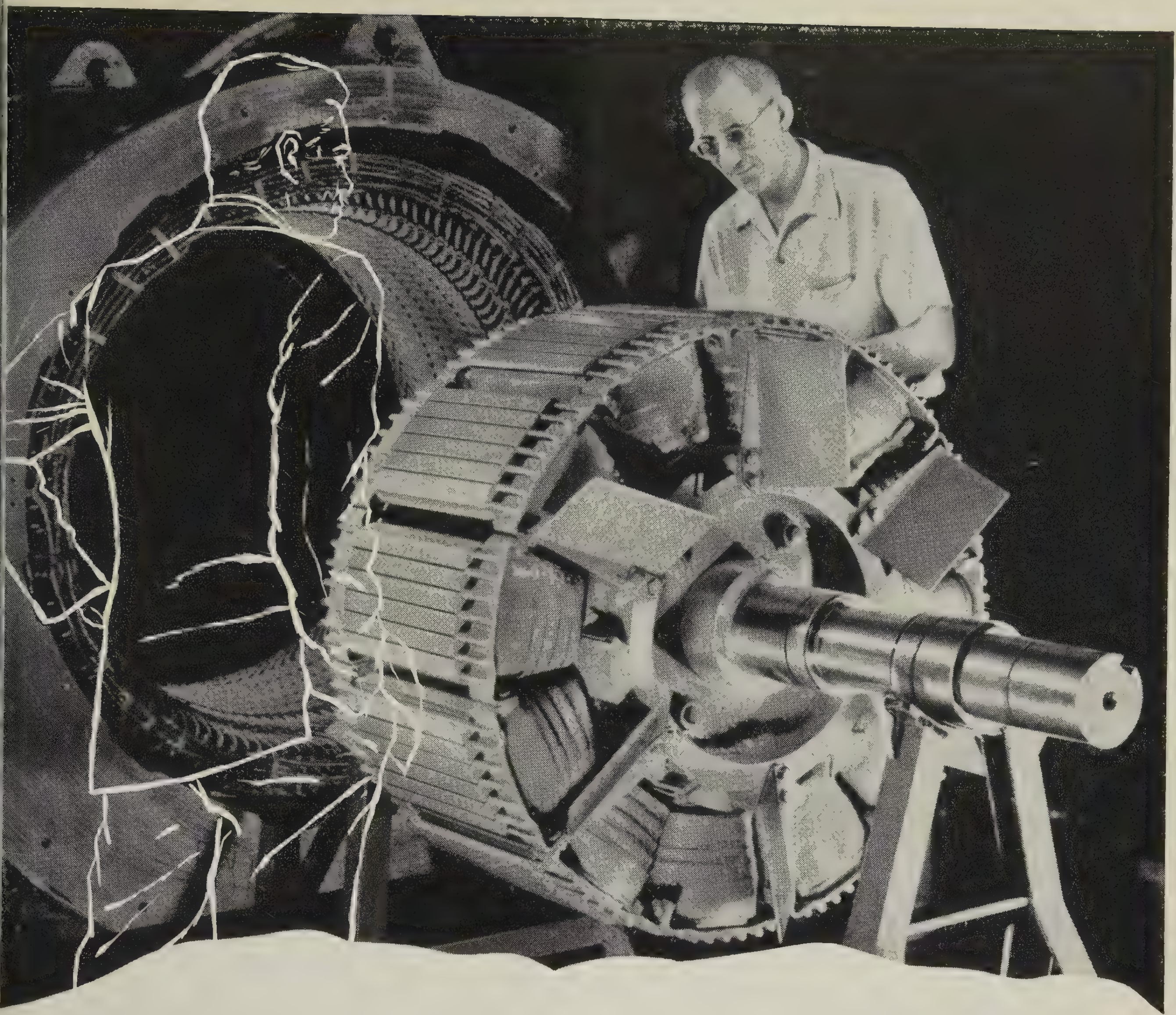
Print No. Ins. 122 on Reader Service Card

Bundling Clamp with Mounting Tab

Wedge lock band clamp, designed to simplify and speed up wire, cable or tubing bundling, is now available



with a separate mounting tab. Because it is not an integral part of the band clamp, the tab need never be in the way at those points along the harness where support is not required. But, at the support points, the tab can be premounted to simplify planning. The band clamp and wiring can then be added later. Or the tab can be slipped on its clamp when the cables are bundled in advance and the entire assembly mounted at once. The all nylon insulating clamp, used by itself or with the mounting tab, is said to provide permanent, vibration-proof holding action. Ratchet teeth on the



band engage with matching teeth inside the clamp loop. Weckesser Co., Dept. IN-2, 5701 Northwest Hwy., Chicago 46.

Print No Ins 123 on Reader Service Card

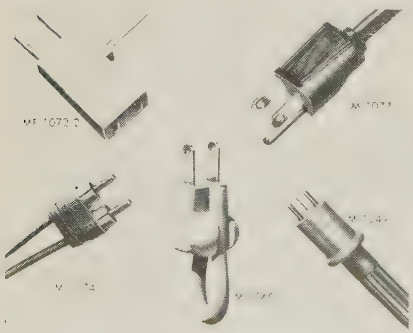
High Reliability, Porcelain-to-Metal Sealed Bushings

A new line of hermetic, high voltage, porcelain-to-metal sealed bushings for use in high reliability capacitors and electronic and distribution transformers are reportedly unique in that the metal parts are bonded directly to the porcelain. The bond achieved permits a mechanically strong, high vacuum-tight assembly. The alloy for the seal between metal and porcelain has a melting point above 300°C, thus making it possible to use these terminals in high temperature electrical equipment. Every bushing is also leak-tested with a mass spectrometer. The porcelain bushings are said to have a considerable cost advantage over alumina ceramic terminals and can also be made in much larger sizes. At present, units from 2″ to 20″ in length have been produced. In quantities of 5,000 to 10,000, price varies from $1.00 to $7.00 each, depending on the size of the terminal. Ceramaseal Inc., New Lebanon Center, N.Y.

Print No. Ins. 124 on Reader Service Card

New Plug Moldings

New plastic molded plugs are available in a choice of colors and can be modified for a variety of electrical purposes. Among the new designs offered are a series or parallel wired male-female combination plug, a straight grounding plug, a 7-pronged special purpose plug, a dual phono plug, and a cord clip plug. In addition to standard line plugs, special plug moldings, with or without wire, can be tailored to specific requirements. Details concerning moldings, wire, cable, and cord sets available. Phalo

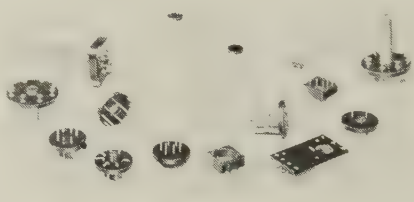


Plastics Corp., Shrewsbury, Mass.

Print No. Ins 125 on Reader Service Card

All-Epoxy Headers for Electronic Applications

An all-epoxy header, once available only as a part of the E-Pak encapsulation system, is now being offered separately. Designed for use with either epoxy shells or conventional metal cases, the header reportedly could replace glass-to-metal hermetic seals in a wide variety of electronic applications. Since the header leads are embedded in cured, molded epoxy, there is no danger of cracked glass, no broken seals, and no coefficient of

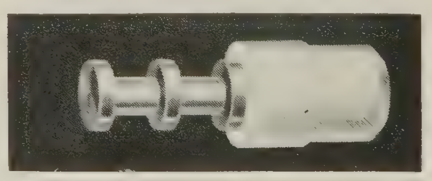


expansion problem during the soldering operation. This is said to reduce assembly time and production rejects. Header leads are embedded to fit a standard seven-pin miniature socket. A wide choice of epoxy formulations is available. Epoxy Products Inc., 137 Coit St., Irvington, N.J.

Print No. Ins. 126 on Reader Service Card

High-Torque "Teflon" Terminal

New Press-Fit terminal designed to withstand higher associated wiring and component pull, type ST-250L4, is of the dual-turret design permitting

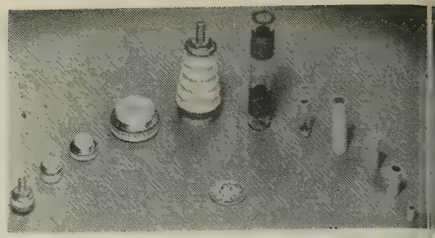


two termination positions with holding collars. It is designed for a maximum chassis thickness of .110″. A mounting hole of .158″ ±.002″ is required. Sealectro Corp., 610 Fayette Ave., Mamaroneck, N.Y.

Print No. Ins. 127 on Reader Service Card

Metalized Ceramic Insulators

A complete line of metalized ceramic insulator components are designed for use in electronic devices such as transistors, diodes, rectifiers, resistors, capacitors, terminals, printed circuits, and transformers. The metalized insulators can be her-

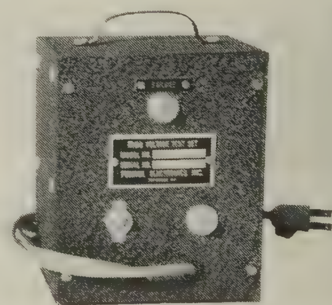


metically sealed into a finished assembly. Conductive coatings of silver and platinum with electroplated coatings of copper, nickel, silver, and tin are available. Components include both steatite and alumina ceramics in tubes, plate rods, and custom shapes. Metalizing Industries Inc., 338 Hudson St., Hackensack, N.J.

Print No. Ins. 128 on Reader Service Card

Small, Inexpensive Hipot Tester

Tester features buzzer and panel light indication of breakdown, grounds, and shorts when testing during manufacture of lighting fixtures, appliances, and components. Other features include self-protection to tester, and automatically current limited output for protection of appliance being tested. Maximum short circuit current is 19 ma. and output voltage

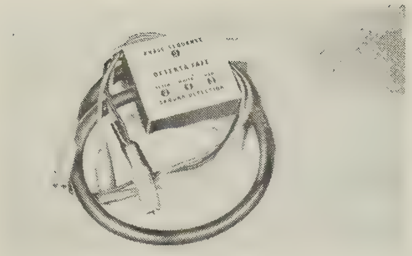


drops to zero when output is shorted. Reliability is enhanced by extreme simplification of tester. Model P1AC-S unit measures 5″ × 6″ × 4″ deep, weighs 6 lbs., and operates from any 115 volt lighting circuit. It is priced at $75.00. The test leads have high voltage insulation and terminate in test prods. Peschel Electronics Inc., Towners, Patterson, N.Y.

Print No. Ins. 129 on Reader Service Card

Phase Sequence Indicator And Ground Fault Detector

The "Detekta-Faze" is designed to predetermine the direction of rotation for any motor without starting the equipment and thereby avoid costly errors and possible injury to personnel by "wrong direction" starts. The ground fault detector in the unit i

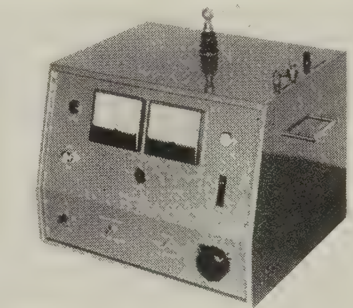


effective for two or three phase-three wire ungrounded systems. It is claimed to be the only instrument available that contains no switches, no moving parts, and no batteries. The compact unit measures only 2¾″ x 2½″ x 1″ and is completely self-contained. Only one light is used for phase detection, and that light is either on or off depending upon the direction of rotation. Detekta-Faze can be used on two phase-three wire systems and three phase-three and four wire systems within an operating range of 200 v to 500 v, 60 cycles a-c. Detkta-Faze has no binding posts. A heavy duty cable is permanently attached to the case and the four color-coded leads each terminate with insulated alligator clips. Price is $19.95. The Glo-Lite Instrument Co., 428 Peshine Ave., Newark 12, N.J.

Print No. Ins. 130 on Reader Service Card

Improved High Potential Test Sets Measure Insulation Breakdown And Leakage

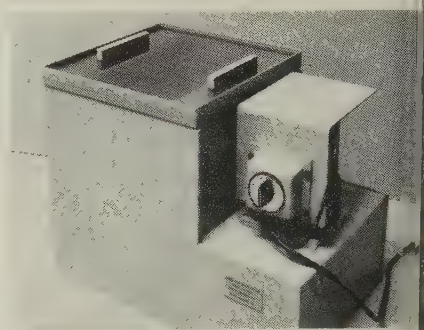
A new series of bench type, semi-portable high potential test sets with outputs to 30 kv, for determining dielectric strength in motors, generators, cables, and switchgear, includes models with either a-c or d-c output. All models provide continuously variable voltage control. Output voltage and insulation leakage current are indicated on separate meters. Many optional features are available, such as automatic rate of rise control, preset automatic cycling, and automatic cut-off at predetermined leakage current limits. Associated Research Inc., 377 W. Belmont Ave., Chicago 18.



Print No. Ins. 131 on Reader Service Card

Printed Circuit Spray Etcher

Model 600 portable spray etche for printed circuits reportedly feature fast and consistent etching for single sided work. It is designed for proto

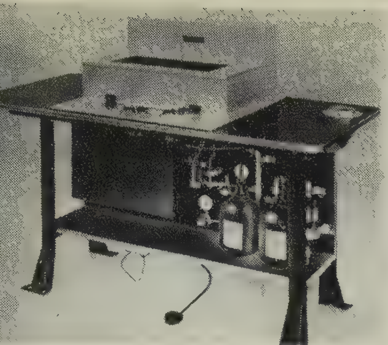


type work. Size is 22½″ x 14¼″ 17¾″ and weight is 45 lbs. Pan sizes are 9″ x 9″. Power is 115V a-c 60 cycles. Centre Circuits Inc., P.O Box 165, State College, Pa.

Print No. Ins. 132 on Reader Service Card

Unit Cleans 600 Parts an Hour

Cobehn precision parts clean (Model RT-S-8-6) is said to critical

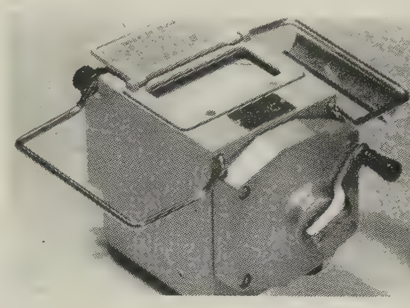


an components and assemblies at rate of 600 units an hour. Parts mounted around the periphery of rotary turntable and automatically lexed to successive, high-velocity, ray-clean operations. A finely atomd spray of Cobehn solvent is comned with heated and filtered air and rected against all areas. Oil, grease, licone lubricants, rosin flux, fingerints, and other contaminants are fely removed in seconds. An inteal ventilation system exhausts all pors. Cobehn solvent is nonflamma-, noncorrosive, nonpolar and nonnic, and will not liberate free chloles to promote oxidation in hertically sealed components. It is completely free of all nonvolatile material. Cobehn Inc., Passaic Ave., Caldwell, N.J.

Print No. Ins. 133 on Reader Service Card

Hand-Cranked Insulation Tester

The model E-17 insulation tester is a hand-cranked, portable type of instrument for the measurement of motor windings, transformer windings, cable harnesses, etc. A variety of ranges from 100 v-10 megohms to



2000 v-5000 megohms are available, also dual voltage and dual range instruments in several combinations. The indicating movement is a ratiometer utilizing a core magnet-type of construction which is said to provide an extremely high torque-to-weight ratio and an unusual immunity to external fields. Ball bearing generators driven through precision gearing provide operating voltage from the hand crank. Accessory motor drive assemblies are available. Eddo Products Corp., 501 Fifth Ave., New York 17.

Print No. Ins. 134 on Reader Service Card

Mechanical Convection Ovens With Improved Control Systems

Outstanding features of new "Pow-er-O-Matic" 60 series of mechanical convection ovens with horizontal air flow include a control system which is said to be stepless, switchless, and infinitely proportional. Temperature is reportedly constant, straight-line, and repetitive throughout the two oven ranges—to 350°F and to 650°F (to 177°C and to 343°C). Other features claimed are extreme reliability, minimum maintenance, and long life. The ovens are wired with voltmeter and circuit breaker. Standard models are available from 1 cu. ft. to 24 cu. ft. (5 sizes). Brochure No. 1960 available. Blue M Electric Co., 138th & Chatham St., Blue Island, Ill.

Print No. Ins. 135 on Reader Service Card

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You can have a personal copy delivered to you if your company is located in the United States and manufactures products of an electrical or electronic nature *in which electrical insulation materials are used* . . . and if you are in purchasing, design, engineering, research, production, testing, management, quality control, etc. Information on paid subscriptions for those not meeting these qualifications on request.

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Booklet on Single Component Epoxy Molding Compounds

New booklet covers a line of low pressure, soft flow, non-outgassing transfer and compression epoxy molding compounds. Molding characteristics, and comprehensive electrical, physical, and chemical properties of the self-extinguishing single component systems are listed. Typical applications are illustrated and described. 12 pages. American-Marietta Co., Adhesive, Resin & Chemical Div., 3400 13th Ave. S. W., Seattle 44, Wash.

Print No. Ins. 201 on Reader Service Card

Glass-Polyester Sheet Prices and Data

New price schedules and technical data for electrical grade thin sheet and custom heavy sheet stocks of fiber glass reinforced polyester incorporate data on several new additions. Thin sheet stocks include a flame retardant UL-recognized glass polyester in thicknesses of 1/32″ and 3/64″ (grade GMM), and three other grades in thicknesses as little as .025″: grade 940 semi-rigid, grade 1300C flexible, and grade FMA flexible. Heavy sheet stocks from ¾ to 2″ thick include a new track resistant, flame resistant grade (grade UTR "Resistrac"), low cost NEMA GPO-1 stock (grade TS), a high strength, flame retardant stock (grade GF), and a standard grade flame retardant, UL-recognized stock (grade UTS). Glastic Corp., 4321 Glenride Rd., Cleveland 21, Ohio.

Print No. Ins. 202 on Reader Service Card

Mica Paper Insulation Literature

Brochure describes "Isomica" mi[ca] paper electrical insulation and e[x]plains temperature characteristics [as] well as other features. Forms covere[d] include molding plate, segment plat[e], flexible plate, heater plate, flexib[le] combinations, tapes, tubes, and c[a]pacitor grade. Insulation applicatio[ns] in commutators, capacitors, coils, c[a]bles, motor slots, resistor cards, an[d] transformers are illustrated. 8 page[s]. Mica Insulator Div., Minnesota Mi[n]ing & Mfg. Co., Schenectady 1, N. [Y.]

Print No. Ins. 203 on Reader Service Card

Epoxy Resin Selection Chart Data Sheets, and Use Information

New literature on "Dolphon" epo[xy] resins for electrical insulating us[e] includes a revised selection cha[rt] folder and data sheets, and a bookl[et] on specific applications. Selecti[on] chart lists paste, impregnating, ca[st]ing and molding, and potting epo[xy] resins with technical data on eac[h]. 4 pages. The technical data fold[er] contains data sheets on one part epo[xy] resins, two part compounds, paste enamel, and cement. Each material [is] described, and electrical and physic[al] properties, use, pot life, and cure i[n]formation are given. 23 pages. T[he] booklet on specific applications co[n]tains discussions and directions f[or] casting stators, casting armatures, p[re]formed field coils, transformers, an[d] coils, and general comments on c[ur]ing, exotherm, fillers, and mold ma[te]rial. 19 pages. John C. Dolph C[o.], Monmouth Junction, N.J.

Print No. Ins. 204 on Reader Service Card

Catalog of Laminated Plastics For Electrical/Electronic Uses

New catalog L-CDL-494 on "Te[x]tolite" industrial laminated plas[tic] sheets, tubes, and rods for electric[al], electronic, and other uses lists app[li]cations, special features, detailed cha[r]acteristics, and sizes available in ov[er]

50 grades. Included are phenolics, silicones, melamines, and epoxies with bases of paper, nylon, cotton, asbestos, and glass fabric. Features and properties of copper-clad laminates for printed circuits are also shown. 16 pages. General Electric Co., Laminated Products Dept., Coshocton, Ohio

Print No. Ins. 205 on Reader Service Card

Catalog of Electrical Insulations For Repair and Maintenance

Revised catalog No. 34 gives prices and descriptions on standard electrical insulation items in a wide range of sizes, colors, and grades for repair and maintenance of motors, generators, transformers, and other electrical or electronic equipment. "Inmanco" cuffed paper in dispenser packages, formed fibre wedges, "Mylar" formed wedges, and hard maple wood wedges are featured. Other products listed include tying cords and twines; woven tapes; flexible tubing and sleeving; mica plates and laminates; varnished fabrics; insulation papers; high temperature insulating materials; varnishes; and pressure-sensitive tapes. The illustrated catalog contains a product index and complete ordering information. 36 pages. Publications Dept., Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6.

Print No. Ins. 206 on Reader Service Card

File Folder on Electrical Papers

New file folder contains product informtaion on many different catagories of electrical papers including insulating, conductive, impregnated and synthetic fiber papers. Some of the special end uses covered are core material, layer and turn insulation, laminating base, and cable wrapping. The folder also lists production and electrical testing facilities. 4 pages. Riegel Paper Corp., 260 Madison Ave., New York City.

Print No. Ins. 207 on Reader Service Card

Catalog on Electrical Resins for Impregnating, Encapsulating, Potting

The first catalog to cover the entire line of commercially available "Sotchcast" brand electrical resins discusses the resins as insulation systems, tells how to select the best resin systems for a job, and lists more than 20 flexible, semiflexible, rigid, and special resins. Typical electrical and other properties, outstanding characteristics, and examples of their applications are given. A section on "Techniques and Tips on the Use of Epoxy Resins" tells how to store and prepare the resins; explains handling, application, and curing techniques; discusses molds and mold releases; and suggests methods of component design and preparation. 28 pages. Dept. WO-10, Minnesota Mining and Manufacturing Co., 900 Bush Ave., St. Paul 6, Minn.

Print No. Ins. 208 on Reader Service Card

Catalog Sheet on Waveguide Windows

New catalog sheet lists electrical and mechanical data for five types of ceramic, glass, or mica windows for use in radar, countermeasure sets, and other equipment employing pressurized waveguide. Each type is illustrated. 2 pages. Sylvania Electric Products Inc., Central Advtg. Distribution Dept., 1100 Main St., Buffalo, N.Y.

Print No. Ins. 209 on Reader Service Card

Bulletin on Flame-Retardant, Copper-Clad, Phenolic Laminates

Bulletin 3.1.25.1 describes copper clad, flame-retardant, paper base-phenolic laminates "Fireban" 321-E (with rolled copper coil) and Fireban 321-E (with electrolytically deposited copper foil). Electrical and punching characteristics are discussed, and properties such as bond strength, dissipation factor, insulation resistance, surface resistivity, and heat resistance are listed. Thickness tolerances of sheets with copper on either one or both sides are also given. 2 pages. Taylor Fibre Co., Norristown, Pa.

Print No. Ins. 210 on Reader Service Card.

Nylon Insulating Bobbin And Washer Brochure

Brochure on nylon insulating bobbins and washers lists complete specifications on flange and core sizes, core lengths, and wall thicknesses for the bobbins; and thicknesses, ID, OD and tolerances of the washers. Advantages are described and many of the 260 nylon bobbins available from stock are illustrated. 4 pages. Cosm Plastics Co., 3239 W. 14th St., Clev

9, Ohio.

No. Ins. 211 on Reader Service Card

tin on Micro-Module Wafers

ew bulletin MMW describes "Fo-ram" micro-module wafers, the ess by which they are produced, r advantages, and their outstand- properties. Features listed include porosity, dimensional stability, k resistance, excellent resistivity, high test resistance. 4 pages. Elec- l Products Div., Corning Glass ks, Corning, N.Y.

No. Ins. 212 on Reader Service Card

Sheet on Ultra High and owave Dielectric Material

ew data sheet discusses and lists rical, chemical, and physical, erties of "Rexolite" 2200, a rein- ed thermosetting plastic insulating erial designed for use at ultra and microwave frequencies in wet and dry locations. Curves dissipation factor, dielectric con- t, and attenuation are included. uses and availability are dis- ed. 2 pages. Rex Corp., Hayward West Acton, Mass.

No. Ins. 213 on Reader Service Card

phlet on Natural Mica

ew pamphlet on "Natural Mica Industry," by Julius A. Bufalino, usses the types of mica used for rical insulation, cost factors, y typical applications, and die- ic and other properties. Visual ity classifications of muscovite are described. 4 pages. Mica In- ry Assn. Inc., 420 Lexington , New York 17.

No. Ins. 214 on Reader Service Card

Booklet on Plastic Shapes, , Tubing, Resins, and Coatings

new booklet outlines electrical other properties, applications, and abilities of milled shapes and ma- ed parts of nylon, "Teflon," cross- d polystyrene, chlorinated poly- , polycarbonate, filled nylon, and ; flexible polyamide tubing and ; sintered parts of TFE, ferro- etic materials, and nylon; filled molding resins; and fluidized coating materials. 16 pages. The ner Corp., 2120 Fairmont Ave., ing, Pa.

No. Ins. 215 on Reader Service Card

Laminated Plastic Tubes, Rods, Sheets, and Parts Catalog

New catalog No. 20.000.13 provides grades, properties, sizes, detailed engineering data, product descriptions, and uses for the complete line of "Insurok" laminated plastic sheets,

printed circuit materials, rods, tubes, and fabricated parts manufactured in NEMA and special grades. Typical fabricated products are illustrated, and manufacturing techniques, research, development, and custom molding are described. 8 pages. The Richardson Co., 2731 Lake St., Melrose Park, Ill.

Print No. Ins. 216 on Reader Service Card

Brochure on Insulating Resins, Varnishes, and Molding Powders

New illustrated brochure CDC-370 describes polycarbonate resins; phenolic resins, varnishes, and molding powders; and fused magnesium oxide for use in electrical insulating and other applications. Complete electrical, physical, and other properties and technical data are listed. 12 pages. Chemical Materials Dept., General Electric Co., One Plastics Ave., Pittsfield, Mass.

Print No. Ins. 217 on Reader Service Card

New Guide to Fabricated Electrical Insulation

New cross-referenced index to a complete line of fabricated electrical insulation, Bulletin 32, describes and illustrates slit insulation, wedges, slot insulation, and fabricated parts in many materials, shapes, and sizes. 8 pages. Inmanco Div., Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6.

Print No. Ins. 218 on Reader Service Card

Print Ins. 59 on Reader Service Card

Insulating Varnish Selection Chart

Revised selection chart for elec trical insulating varnishes lists elec trical and other characteristics applicable military specifications, rec ommended applications, and com patibility with magnet wire coating of baking varnishes, epoxy resin var nish, air drying varnishes, red insu lators, and epoxy enamel. 4 pages John C. Dolph Co., Monmouth Junc tion, N.J.

Print No. Ins. 219 on Reader Service Card

Electrical Reference Tables And Appointment Calendar

New spiral-bound daily appoin ment calendars contain an electric reference table section. The desk-siz $8\frac{3}{4}''$ by $6\frac{7}{8}''$ calendars provid room for day-to-day appointmen as well as tables showing mot load for full load current, condu data, properties of copper conductor allowable current carrying capacit in amperes, number of conductors conduit or tubing, building wires an power cables, flexible cords and fi ture wires, and electrical events 1960. Dept. IS, Hatfield Wire & Cab Div., Continental Copper & Steel I dustries Inc., Hillside, N.J.

Print No. Ins. 220 on Reader Service Card

Catalog Sheet on High Potential Test Sets

New catalog sheet describes Mod 570 (portable) and 570RP (ra panel) megpot high potential test se for nondestructive dielectric testir Outstanding features, characteristi and general specifications are d scribed, and voltage ratings availab and physical dimensions are liste 2 pages. General Hermetic Seali Corp., 99 E. Hawthorne Ave., Vall Stream, L.I., N.Y.

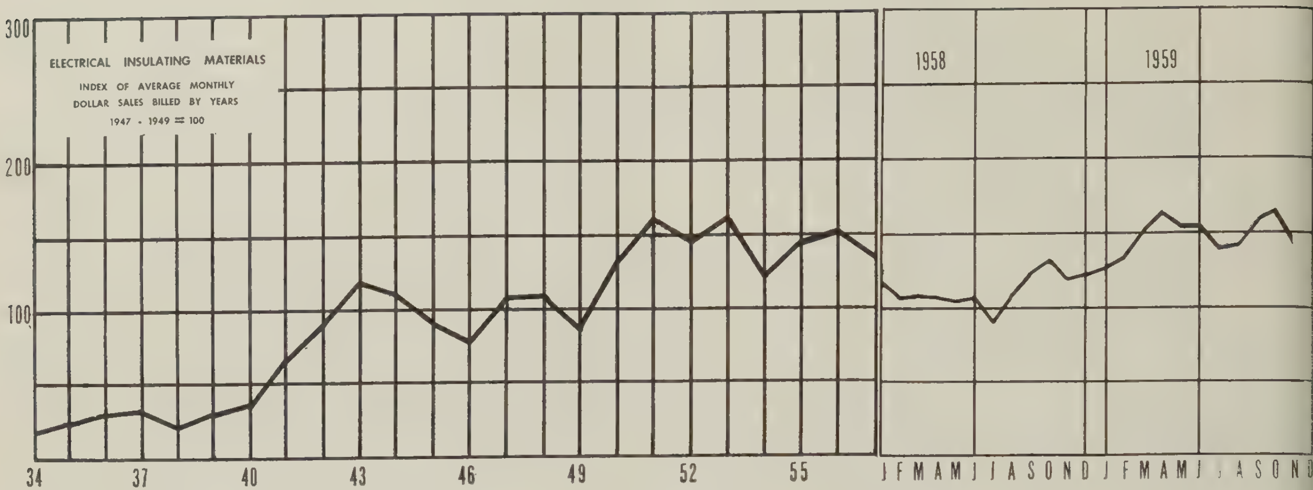
Print No. Ins. 221 on Reader Service Card

Bulletin on Component Cleaning

Booklet describes and illustra how to achieve chemical cleanlin for components and parts in the ele tronic and electro-mechanical fiel Actual applications of the method a illustrated in the booklet, and illust tions are also shown of the equipme and the solvent used. 8 pages. Cobe Inc., Passaic Ave., Caldwell, N.J.

Print No. Ins. 222 on Reader Service Card

NEMA Electrical Insulation Index



	Nov. 59	Oct. '59	Nov. '58
Index series	141	164	121
Nov. '59 point change from other mos.		—23	+20
Nov. 59 % change from other months		—14	+17

Index is based on 1947-1949 average month, inclusive= 100

Published through the courtesy of the National Electrical Manufacturers Association

Materials Used in Electrical Insulation Index

Industrial Laminated Products

Manufactured Electrical Mica

Varnished Fabric and Paper

Vulcanized Fibre

Varnished Tubing and Saturated Sleeving (From M 1952)

Dates to Circle

Meeting and Convention Notices

r. 21-23 . . . First National Electric .ouse Heating Exposition, Electric House [eating Equipment Section, NEMA, herman Hotel, Chicago.

r. 21-24 . . . IRE, National Convention, oliseum and Waldorf-Astoria Hotel, lew York City.

:. 23-26 . . . Electrical Maintenance ngineers Assn. of Southern California, lectrical Industry Show and Lighting xposition, Shrine Exposition Hall, Los ngeles.

:. 30-Apr. 1 . . . American Power Con- erence, sponsored by AIEE and ASME, herman Hotel, Chicago.

. 4-6 . . . AIEE, Southwest District [eeting, Shamrock Hilton Hotel, Hous- on, Texas.

. 4-8 . . . Nuclear Congress, Engineers oint Congress, sponsored by AIEE, IRE, nd ACM, Coliseum, New York, N.Y.

. 5-9 . . . Ninth Electrical Engineers xhibition, Assn. of Supervising Electri- al Engineers, Earls Court, London.

. 6-8 . . . Institute of Environmental ciences, National Meeting and Exhibit, iltmore Hotel, Los Angeles.

. 7-8 . . . SPI, 17th Western Section onference, New Riviera Hotel, Palm prings, Calif.

. 12-14 . . . AIEE, Electrical Engineer- g in Space Technology Conference, otel Baker, Dallas, Texas.

. 12-14 . . . AIEE, East Central District [eeting, Daniel Boone Hotel, Charles- on, W. Va.

. 20-22 . . . SPI, Third Annual Fluoro- rbon Division Meeting, Hotel Roose- elt, New Orleans, La.

. 20-22 . . . Twelfth Annual South- estern Conference and Electronics how, sponsored by Houston Section, RE, Shamrock Hilton Hotel, Houston, exas.

Apr. 25-26 . . . SPI, 18th Annual Canadian Section Conference, London Hotel, London, Ont., Canada.

Apr. 25-29 . . . American Welding Society, Annual Meeting and Welding Show, Biltmore Hotel and Great Western Exhibit Center, Los Angeles.

Apr. 27-29 . . . AIEE, Great Lakes District Meeting, Pfister Hotel, Milwaukee, Wis.

May 1-5 . . . National Assn. of Electrical Distributors, 52nd Annual Convention, Memorial Auditorium, Dallas.

May 1-5 . . . Electrochemical Society, Technical Meeting, La Salle Hotel, Chicago.

May 2-4 . . . AIEE, North Eastern District meeting, Sheraton Biltmore Hotel, Providence, R.I.

May 2-4 . . . IRE, National Aeronautical Electronics Conference, Biltmore and Miami-Pick Hotels, Dayton, Ohio.

May 3-5 . . . Western joint Computer Conference, sponsored by AIEE, IRE, and ACM, Jack Tar Hotel, San Francisco, Cal.

May 4-5 . . . The Wire Assn., Electric Wire & Cable Section Regional Meeting, Sheraton Hotel, Philadelphia.

May 7-13 . . . SPI, Annual Conference, S. S. Queen of Bermuda (business sessions held at sea during New York City-Bermuda cruise).

May 8-11 . . . NISA, Annual Convention, Hotel Fontainebleau, Miami Beach, Fla.

May 10-12 . . . Electronic Components Conference, sponsored by AIEE, IRE, EIA, and WCEMA, Hotel Washington, Washington, D.C.

May 12-13 . . . SPI, National Plastics Molder & Suppliers Conference, American Hotel, Bal Harbour, Fla.

May 16-18 . . . IRE, 7th Retec and Trade Show, Olympic Hotel, Seattle, Wash.

June 10-26 . . . British Exhibition of Industry, Technology, Science, and Culture, sponsored by the Federation of British Industries, Coliseum, New York City.

Abbreviations Used in Notices

.IEE	—American Institute of Electrical Engineers
.STM	—American Society for Testing Materials
.SME	—American Society of Mechanical Engineers
.SA	—American Standards Assn.
RE	—Institute of Radio Engineers
IA	—Electronic Industries Assn.
NEMA	—National Electrical Manufacturers Assn.
NISA	—National Industrial Service Assn.
SPE	—Society of Plastics Engineers
SPI	—Society of the Plastics Industry
WCEMA	—West Coast Electronic Manufacturers Assn.

Advertisers' Index

To obtain more information on products of Insulation *advertisers, just print the advertisement number shown for each advertiser in one of the spaces on the Reader Service Inquiry Card on the inside back cover. This number appears under each advertisement and is also repeated in the listing below. After filling out the card completely, tear it off and drop it in the mail—no postage required.* Insulation *will promptly forward your requests for further information to the advertisers.*

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Ins. 14	Rubber & Asbestos Corp.	
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Ins. 21	Southern Weaving Co.	
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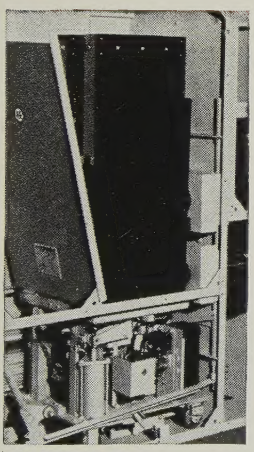
New York 17, N.Y.—Robert Bandini
41 E. 42nd St. Phone MUrray Hill 2-3157

San Marino, Calif.—H. L. Mitchell & Assoc.
1450 Lorain Road. Phone CUmberland 3-4394

Oakland 18, Calif.—James T. Stevenson
5901 Buena Vista Ave. Phone OLympic 3-8602

Now, a breakthrough in protection for apparatus operating under humid, contaminated conditions. Tests show that RESISTRAC insulating members *do not track* after hundreds of times the exposure required to fail phenolic (illustrated).

New GLASTIC RESISTRAC*
Fiber Glass Alumina-Polyester



RESISTRAC is used in *Allis-Chalmers* high voltage switchgear.

Far greater fault protection—especially in humid, contaminated atmospheres—is available in apparatus insulated with Glastic RESISTRAC.

This new alumina-filled polyester insulation has more than 1500 times the track resistance of phenolic laminates, 30 times the resistance of conventional fiber glass polyesters, as shown in the suggested ASTM dust and fog tracking test.

In addition to outstanding track resistance, RESISTRAC has superior flame retardance, low water absorption, low power factor, and excellent physical properties typical of all glass reinforced polyester materials.

It has received immediate acceptance. RESISTRAC parts—sheet, moldings and structural shapes—are already in use in 5 and 15 KV metal clad switchgear made by three major suppliers.

Discover *all* the advantages of this new advance in insulating materials. Ask your apparatus supplier about RESISTRAC. And write us for complete engineering data.

*Trade Mark. Users of Glastic RESISTRAC are licensed for its application as covered in U. S. Patent 2,768,264.

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